Illustrations for Joint Agency CSRUH

As of 08 September 2014

Figure 1-1

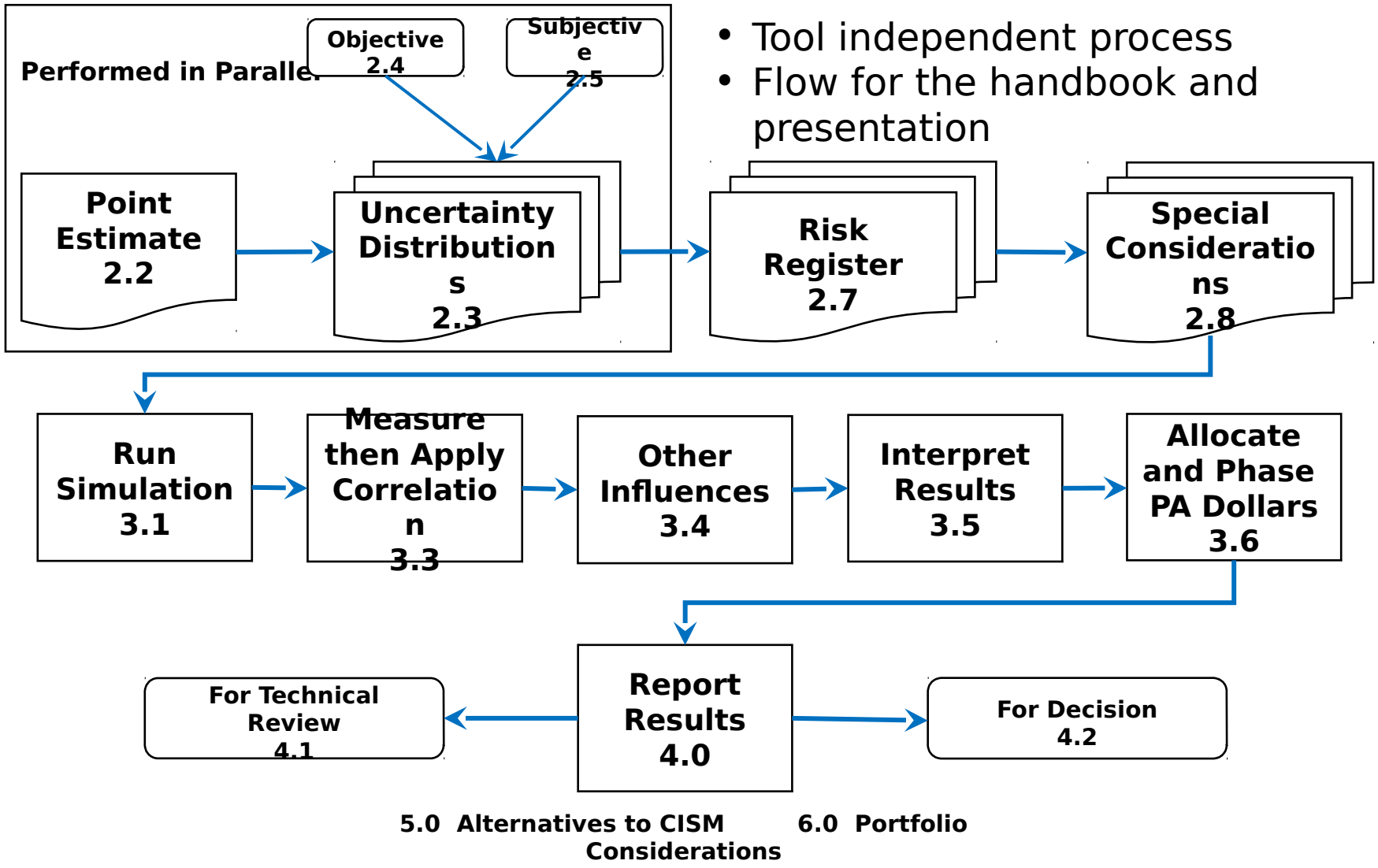

Performed in Paralle
Objective 2.4
Subjectiv e 2.5
Point Estimate 2.2
Uncertainty Distribution s 2.3
Risk Register 2.7
Special Consideratio ns 2.8
Tool independent process
Flow for the handbook and presentation
Run Simulation 3.1
Measure then Apply Correlatio n 3.3
Other Influences 3.4
Interpret Results 3.5
Allocate and Phase PA Dollars 3.6
For Technical Review 4.1
Report Results 4.0
For Decision 4.2
5.0 Alternatives to CISM Considerations
6.0 Portfolio

Figure 1-2

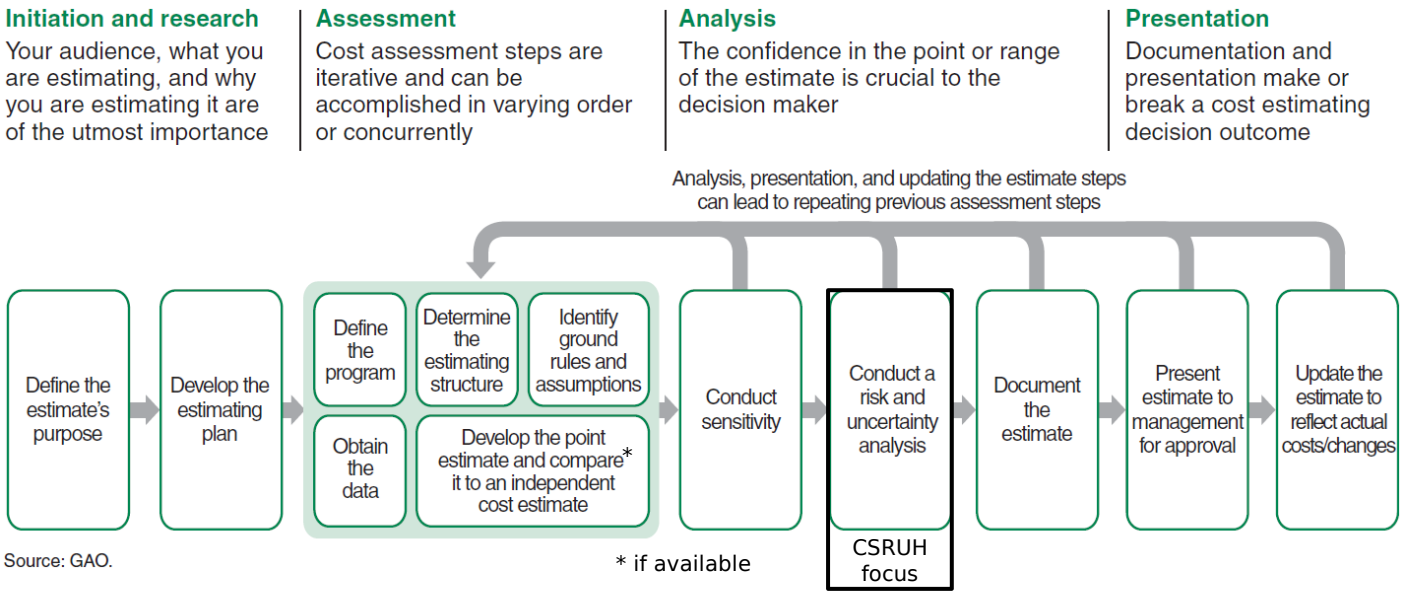

Initiation and research
Your audience, what you are estimating, and why you are estimating it are of the utmost importance
Assessment
Cost assessment steps are iterative and can be accomplished in varying order or concurrently
Analysis
The confidence in the point or range of the estimate is crucial to the decision maker
Presentation
Documentation and presentation make or break a cost estimating decision outcome
Analysis, presentation, and updating the estimate steps can lead to repeating previous assessment steps
Define the estimate's purpose
Develop the estimating plan
Define the program
Determine the estimating structure
Identify ground rules and assumptions
Obtain the data
Develop the point estimate and compare* it to an independent cost estimate
Conduct sensitivity
Conduct a risk and uncertainty analysis
Document the estimate
Present estimate to management for approval
Update the estimate to reflect actual costs/changes
CSRUH focus
Source: GAO.
* if available

Figure 1-2
(alternate)

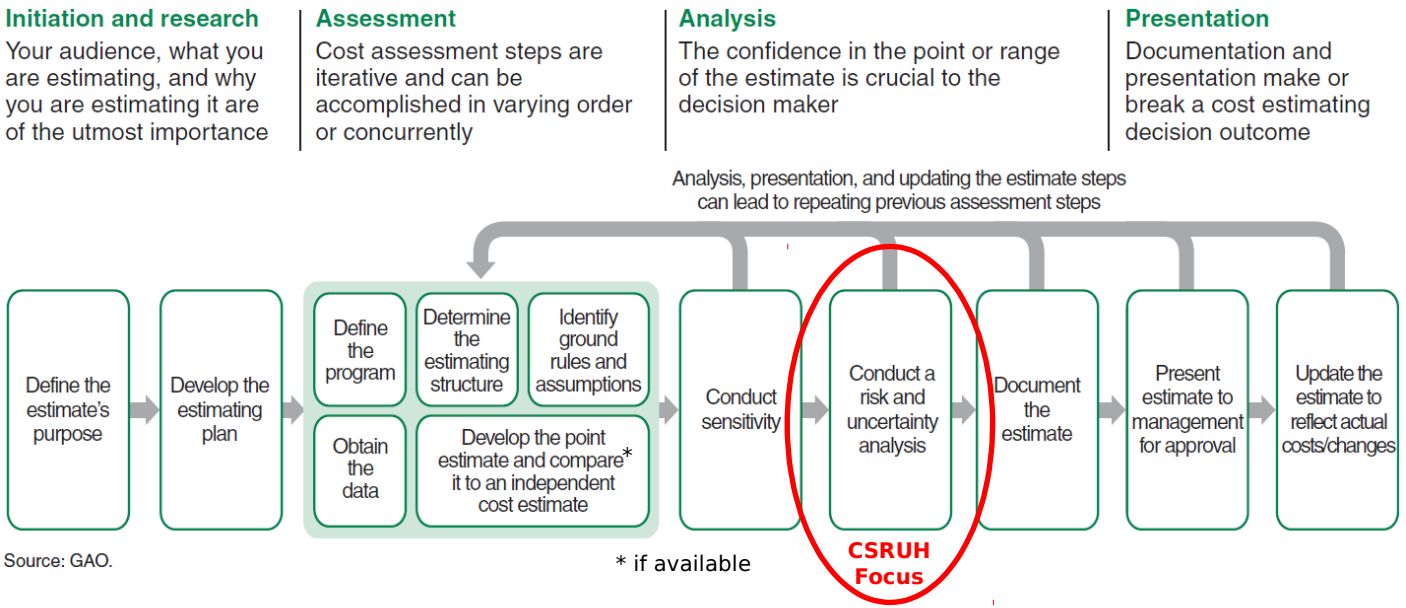


Figure 1-3

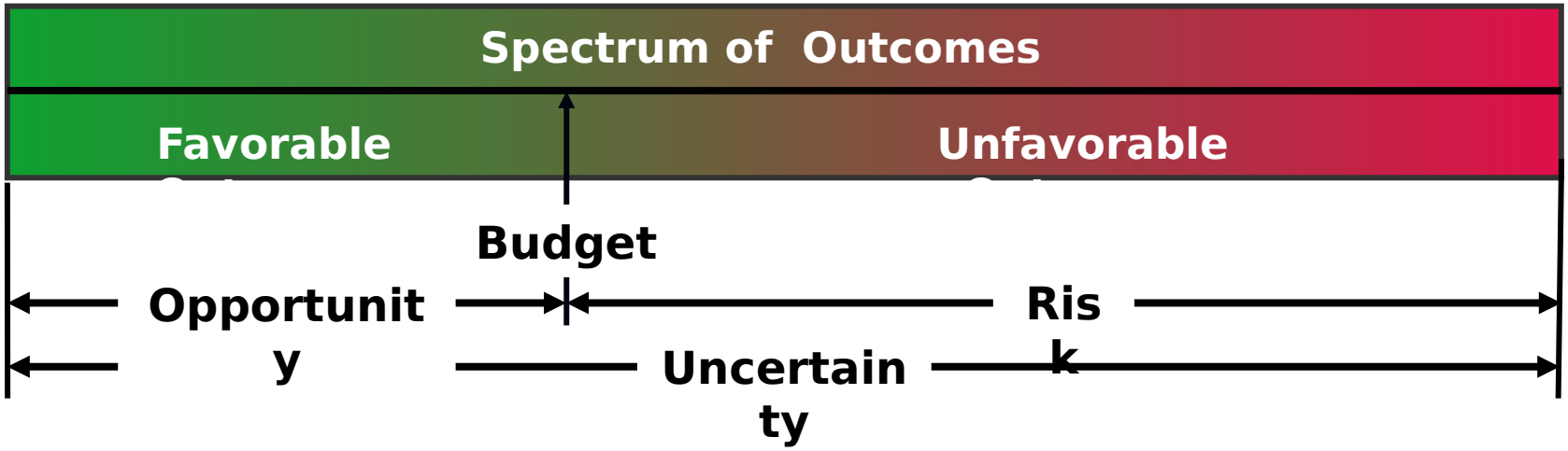

Spectrum of Outcomes
Favorable
Unfavorable
Budget
Opportunit
y
Ris
k
Uncertain
ty

Figure 2-1

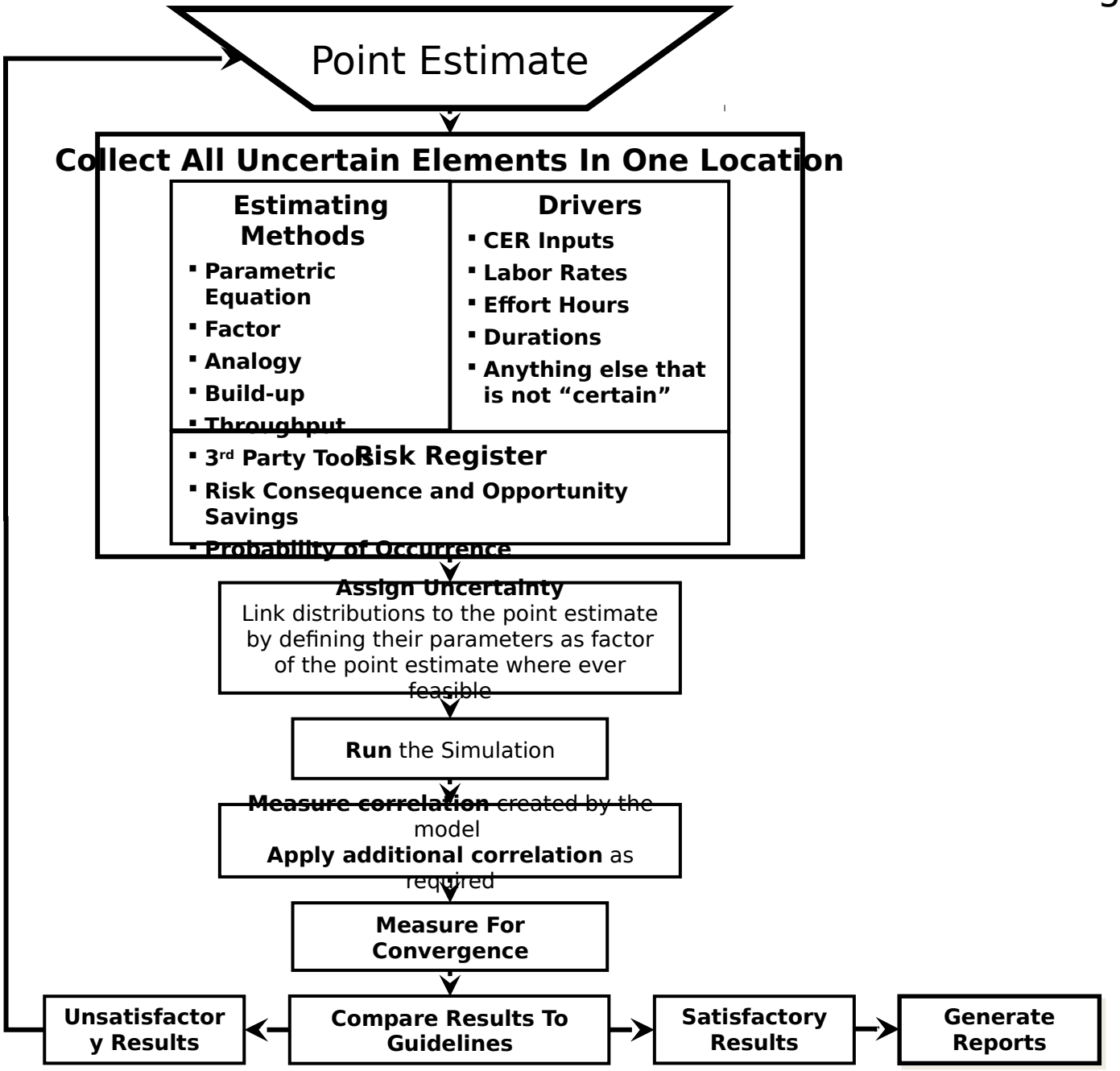
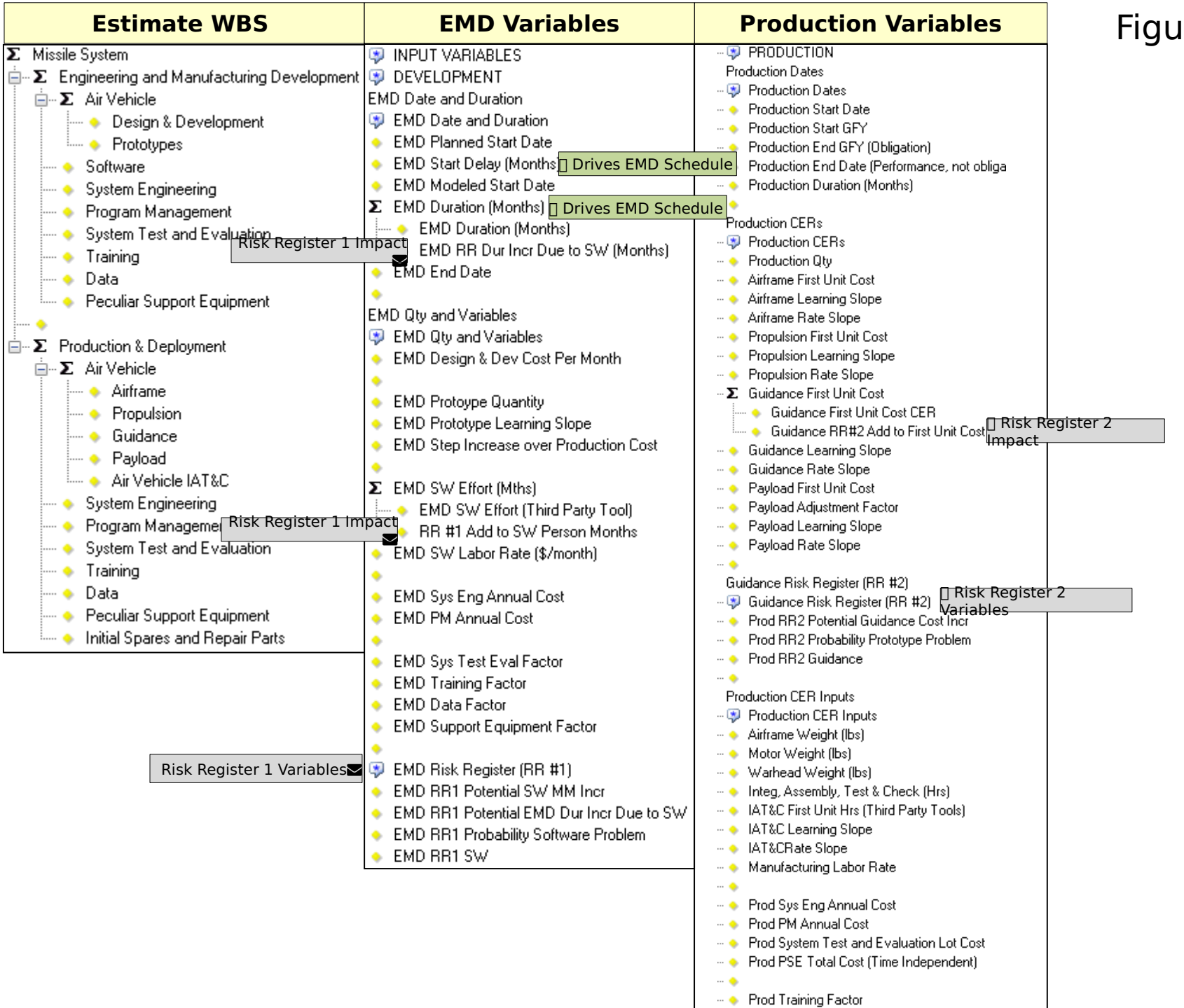

Point Estimate
Collect All Uncertain Elements In One Location
Estimating Methods
Parametric Equation
Factor
Analogy
Build-up
Throughput
Drivers
CER Inputs
Labor Rates
Effort Hours
Durations
Anything else that is not "certain"
Risk Register
3rd Party Tools
Risk Consequence and Opportunity Savings
Probability of Occurrence
Assign Uncertainty
Link distributions to the point estimate by defining their parameters as factor of the point estimate where ever feasible
Run the Simulation
Measure correlation created by the model
Apply additional correlation as required
Measure For Convergence
Unsatisfactory Results
Compare Results To Guidelines
Satisfactory Results
Generate Reports

Figure 2-2


Estimate WBS
EMD Variables
Production Variables
Missile System
Engineering and Manufacturing Development
Air Vehicle
Design & Development
Prototypes
Software
System Engineering
Program Management
System Test and Evaluation
Training
Data
Peculiar Support Equipment
Production & Deployment
Air Vehicle
Airframe
Propulsion
Guidance
Payload
Air Vehicle IAT&C
System Engineering
Program Management
System Test and Evaluation
Training
Data
Peculiar Support Equipment
Initial Spares and Repair Parts
INPUT VARIABLES
DEVELOPMENT
EMD Date and Duration
EMD Date and Duration
EMD Planned Start Date
EMD Start Delay (Months)
Drives EMD Schedule
EMD Modeled Start Date
EMD Duration (Months)
Drives EMD Schedule
EMD Duration (Months)
EMD RR Dur Incr Due to SW (Months)
EMD End Date
EMD Qty and Variables
EMD Qty and Variables
EMD Design & Dev Cost Per Month
EMD Protoype Quantity
EMD Prototype Learning Slope
EMD Step Increase over Production Cost
EMD SW Effort (Mths)
EMD SW Effort (Third Party Tool)
RR #1 Add to SW Person Months
EMD SW Labor Rate ($/month)
EMD Sys Eng Annual Cost
EMD PM Annual Cost
EMD Sys Test Eval Factor
EMD Training Factor
EMD Data Factor
EMD Support Equipment Factor
EMD Risk Register (RR #1)
EMD RR1 Potential SW MM Incr
EMD RR1 Potential EMD Dur Incr Due to SW
EMD RR1 Probability Software Problem
EMD RR1 SW
Risk Register 1 Impact
Risk Register 1 Impact
Risk Register 1 Variables
PRODUCTION
Production Dates
Production Dates
Production Start Date
Production Start GFY
Production End GFY (Obligation)
Production End Date (Performance, not obliga
Production Duration (Months)
Production CERs
Production CERs
Production Qty
Airframe First Unit Cost
Airframe Learning Slope
Ariframe Rate Slope
Propulsion First Unit Cost
Propulsion Learning Slope
Propulsion Rate Slope
Guidance First Unit Cost
Guidance First Unit Cost CER
Guidance RR#2 Add to First Unit Cost
Risk Register 2 Impact
Guidance Learning Slope
Guidance Rate Slope
Payload First Unit Cost
Payload Adjustment Factor
Payload Learning Slope
Payload Rate Slope
Guidance Risk Register (RR #2)
Guidance Risk Register (RR #2)
Risk Register 2 Variables
Prod RR2 Potential Guidance Cost Incr
Prod RR2 Probability Prototype Problem
Prod RR2 Guidance
Production CER Inputs
Production CER Inputs
Airframe Weight (lbs)
Motor Weight (lbs)
Warhead Weight (lbs)
Integ, Assembly, Test & Check (Hrs)
IAT&C First Unit Hrs (Third Party Tools)
IAT&C Learning Slope
IAT&CRate Slope
Manufacturing Labor Rate
Prod Sys Eng Annual Cost
Prod PM Annual Cost
Prod System Test and Evaluation Lot Cost
Prod PSE Total Cost (Time Independent)
Prod Training Factor

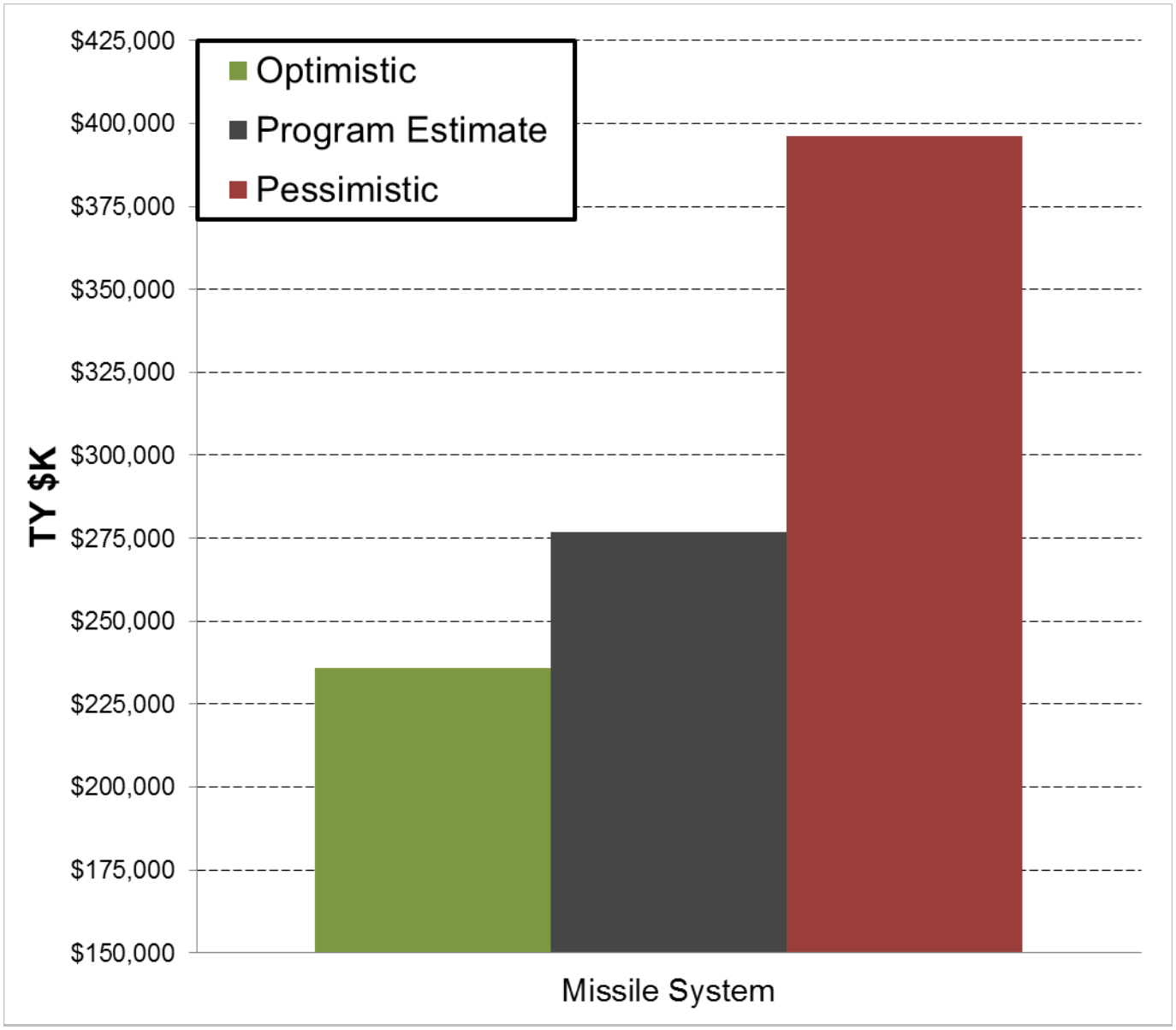

$425,000
$400,000
$375,000
$350,000
$325,000
$300,000
$275,000
$250,000
$225,000
$200,000
$175,000
$150,000
TY $K
Optimistic
Program Estimate
Pessimistic
Missile System

Table 2-2

DISTRIBUTION	TYPICAL APPLICATION	KNOWLEDGE OF MODE	NUMBER OF PARAMETERS REQUIRED	RECOMMENDED PARAMETERS
Lognormal	**Default** when no better info. Probability skewed right. Replicate another model result. Power OLS CER uncertainty.	Mean or median known better than the mode	2	**Median, high** (some tools have a 3rd parameter : "Location" . By default, it is zero. Used to "shift" the lognormal left or right (even into negative region)
Log-t	Log-t when < 30 data points		3	**Add Degrees of Freedom**
Triangular	Expert opinion. Finite min/max. Probability reduces towards endpoints. Skew possible. Labor rates, labor rate adjustments, factor methods	Good idea	3	**Low, mode, and high**
BetaPert	Like triangular, but mode is 4 times more important than min or max.	Very good idea	3	**Low, mode, and high**
Beta	Like triangular, but min/max region known better than mode.	Not sure	4	**Min, low, high, and max**
Normal	Equal chance low/high. Unbounded in either direction Linear OLS CER uncertainty.	Good idea, but unbounded in either direction	2	**Mean/Median/Mode and high value**
Student's-t	t when < 30 data points		3	**Add Degrees of Freedom**
Uniform	Equal chance over uncertainty range. Finite min/max.	No idea	2	**Low and High** (some tools require min and max)
Empirical Fit	Unable to fit a distribution to the data	Not required	N/A	**Enter source data and estimated probability for each data point**

Note: *Low/high* are defined with an associated percentile
Min/Max are the absolute lower/upper bound (also known as the 0/100)

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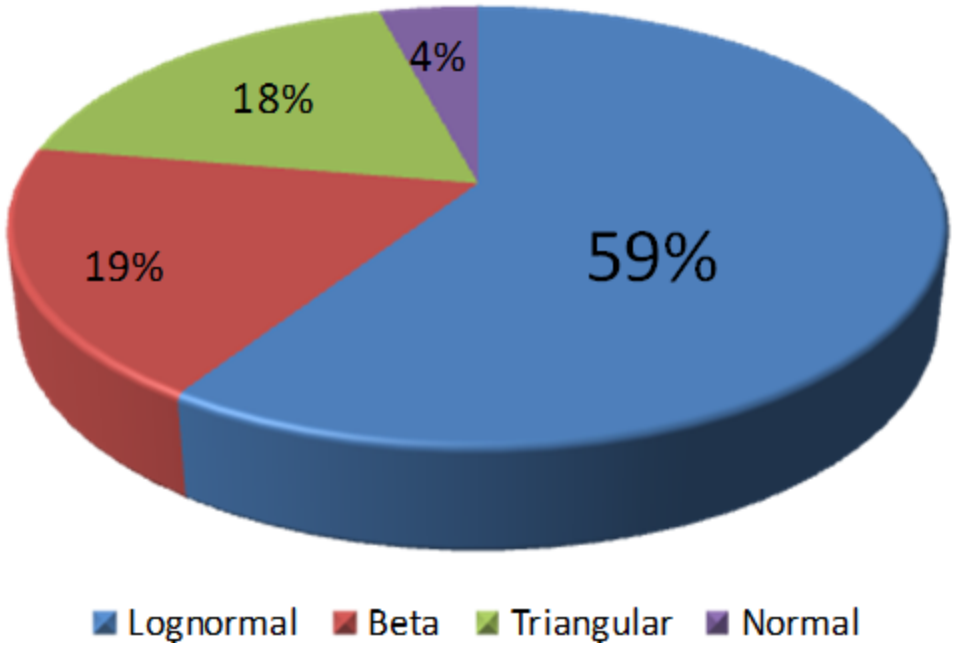
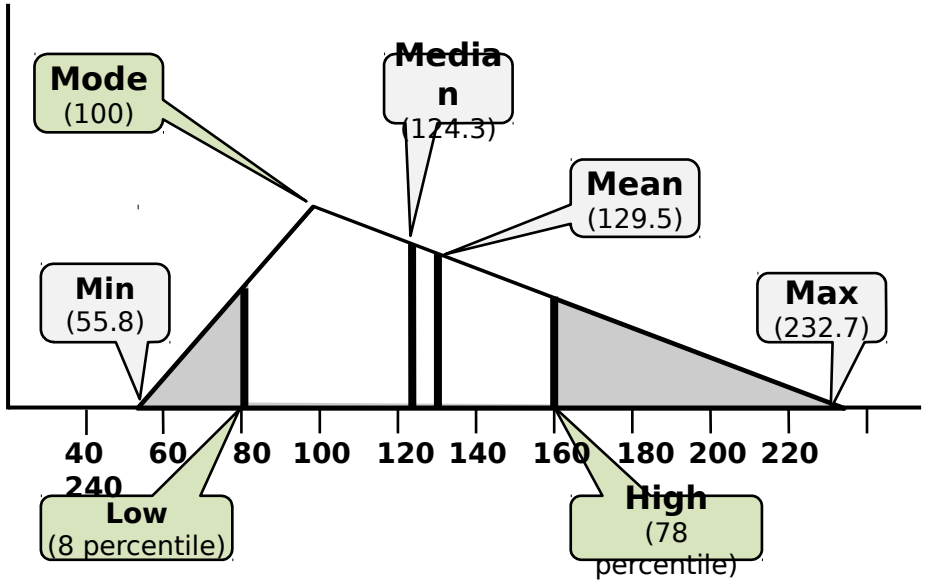
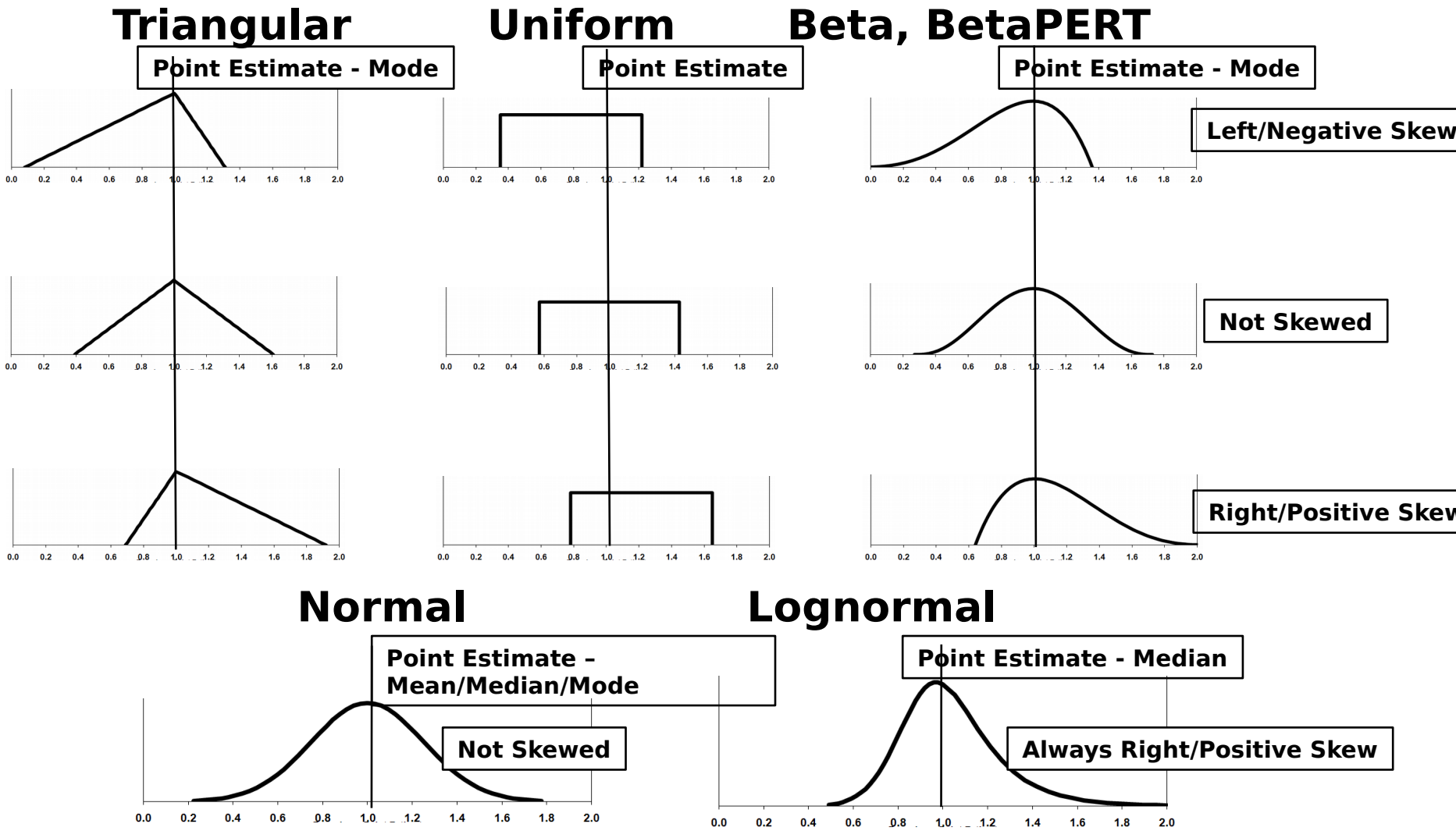
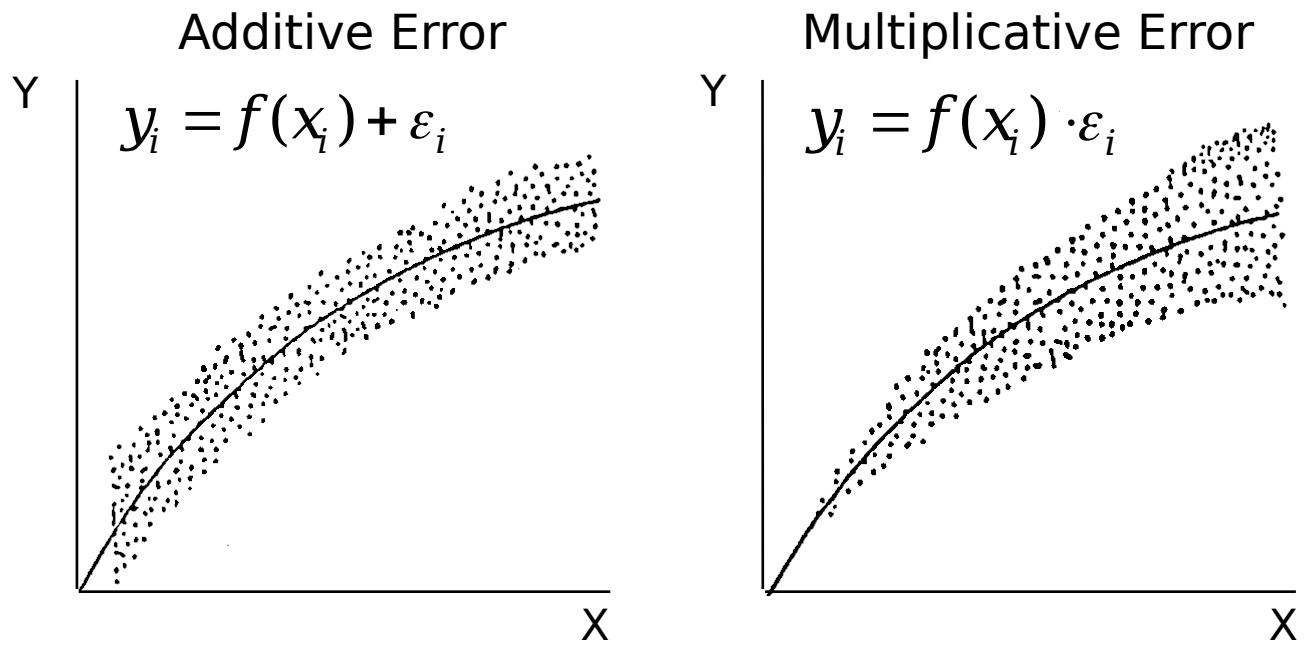
Figure 2-6



8%
78%
56
233
129.5
124.3
114.7
144.2




Triangular
Uniform
Beta, BetaPERT
Point Estimate - Mode
Point Estimate
Point Estimate - Mode
Left/Negative Skew
Not Skewed
Right/Positive Skew
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
Normal
Lognormal
Point Estimate – Mean/Median/Mode
Not Skewed
Point Estimate - Median
Always Right/Positive Skew



Reference: **H.L. Eskew and K.S. Lawler, "Correct and Incorrect Error Specifications in Statistical Cost Models," Journal of Cost Analysis, Spring 1994, page 107.**

Figure 2-11

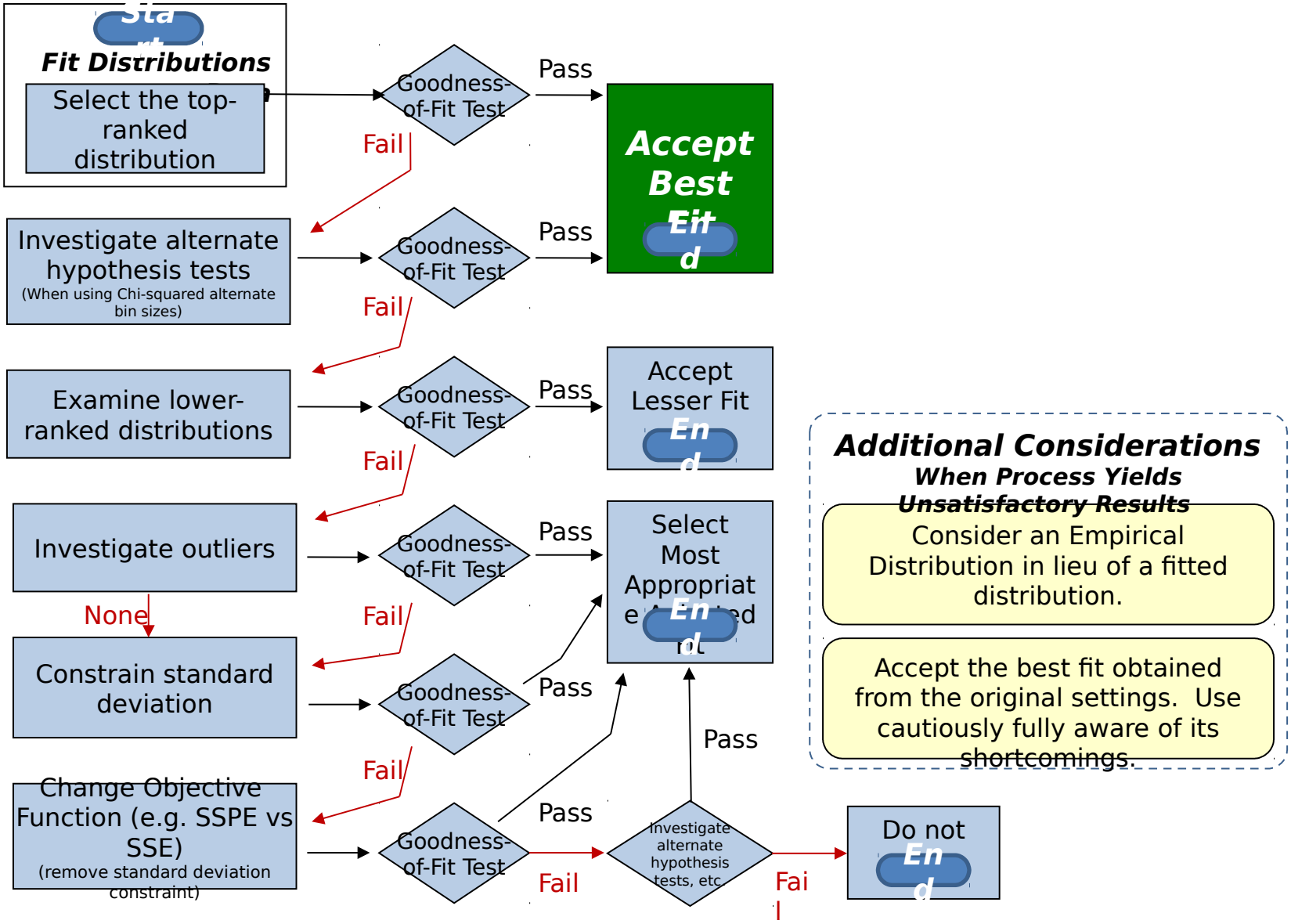
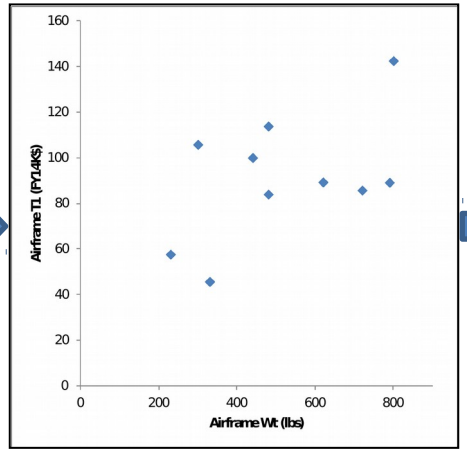

Start
Fit Distributions
Select the top-ranked distribution
Goodness-of-Fit Test
Pass
Accept Best Fit
End
Fail
Investigate alternate hypothesis tests
(When using Chi-squared alternate bin sizes)
Goodness-of-Fit Test
Pass
Fail
Examine lower-ranked distributions
Goodness-of-Fit Test
Pass
Accept Lesser Fit
End
Fail
Investigate outliers
Goodness-of-Fit Test
Pass
Select Most Appropriate Method
End
None
Fail
Constrain standard deviation
Goodness-of-Fit Test
Pass
Fail
Change Objective Function (e.g. SSPE vs SSE)
(remove standard deviation constraint)
Goodness-of-Fit Test
Pass
Investigate alternate hypothesis tests, etc
Pass
Fail
Fail
Do not
End
Additional Considerations
When Process Yields Unsatisfactory Results
Consider an Empirical Distribution in lieu of a fitted distribution.
Accept the best fit obtained from the original settings. Use cautiously fully aware of its shortcomings.

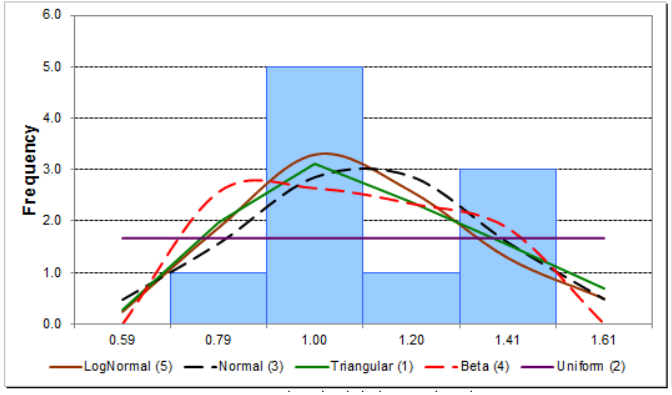
Figure 2-12

	Airframe Wt (lbs)	First Unit Cost $K2014
System #7	230	57.8
System #10	300	105.9
System #6	330	45.8
System #4	440	100.1
System #3	480	113.9
System #8	480	84.1
System #2	620	89.4
System #1	720	85.9
System #9	790	89.3
System #5	800	142.7



	Residual	CDF
System #6	0.5880	5%
System #9	0.8091	15%
System #1	0.8093	25%
System #7	0.8446	35%
System #2	0.8969	45%
System #8	0.9353	55%
System #4	1.1526	65%
System #3	1.2674	75%
System #5	1.2860	85%
System #10	1.4089	95%

	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.9398	1.0045	0.9398	1.0004	1.0003	0.9398
StdDev	0.2636	0.2599	0.2588	0.2510	0.2464	0.2446
CV	0.2636	0.2587	0.2589	0.2509	0.2463	0.2446
Min	0.5880			0.4760	0.6039	0.5762
Mode		0.9115	0.9398	0.8484	0.6733	
Max	1.4089			1.6770	1.5152	1.4234
Alpha					1.0276	
Beta					1.3347	
Data Count	10	% < 0 =	0.01%	None	None	None
Standard Error of Estimate		0.0699	0.0671	0.0642	0.0698	0.0643
Rank		5	3	1	4	2
SEE / Fit Mean		6.95%	6.71%	6.42%	6.98%	6.43%
Chi^2 Fit test 9 Bins, Sig 0.05		Good (24%)	Good (24%)	Good (28.7%)	Good (9%)	Good (24%)



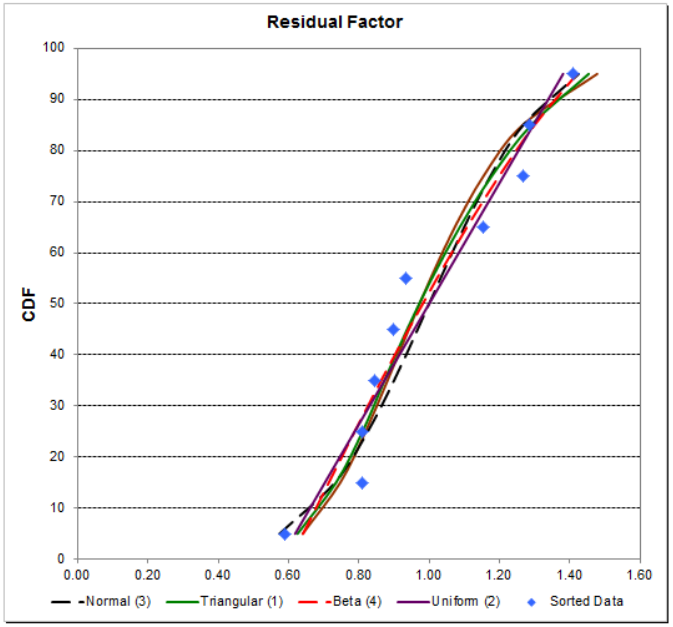
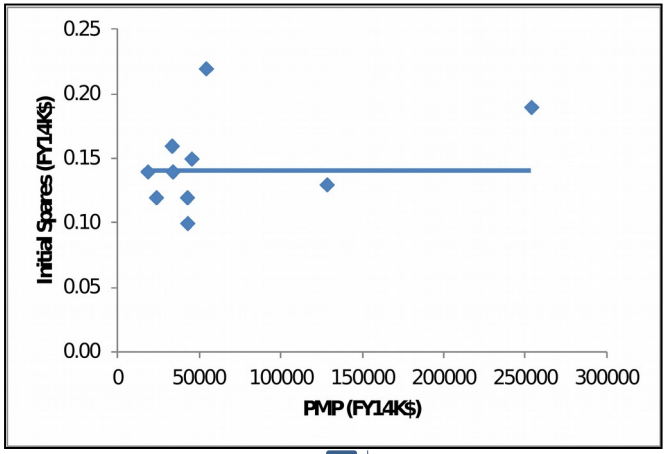
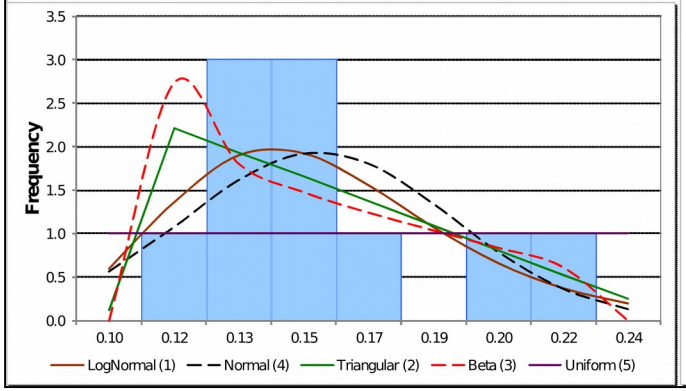


Figure Not Used

	Initial Spares $	PMP $	Initial Spares Factor
System #3	2432	18000	0.14
System #1	2752	23200	0.12
System #6	5286	32861	0.16
System #2	4570	33355	0.14
System #4	4948	42252	0.12
System #7	4240	42399	0.10
System #5	6545	44964	0.15
System #8	11693	53850	0.22
System #10	16645	128040	0.13
System #9	47566	253700	0.19
Median			0.14



	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	0.1470	0.1474	0.1469	0.1473	0.1461	0.1511
StdDev	0.0356	0.0369	0.0351	0.0341	0.0352	0.0398
CV	0.2422	0.2506	0.2390	0.2313	0.2410	0.2630
Min	0.1000			0.0982	0.1000	0.0823
Mode	0.1200	0.1345	0.1469	0.1000		
Max	0.2200			0.2436	0.2329	0.2200
Alpha					0.7728	
Beta					1.4560	
Data Count	10	% < 0 =	0.00%	None	None	None
Standard Error of Estimate		0.0057	0.0096	0.0072	0.0088	0.0152
Rank		1	4	2	3	5
SEE / Fit Mean		3.86%	6.55%	4.87%	6.02%	10.02%
Chi^2 Fit test 5 Bins, Sig 0.05		Good (37%)	Good (37%)	Good (16%)	Unknown	Good (14%)



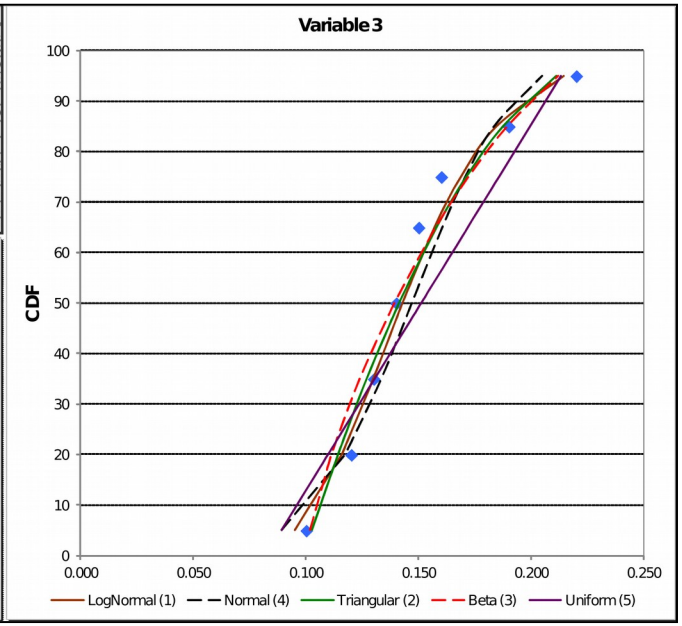
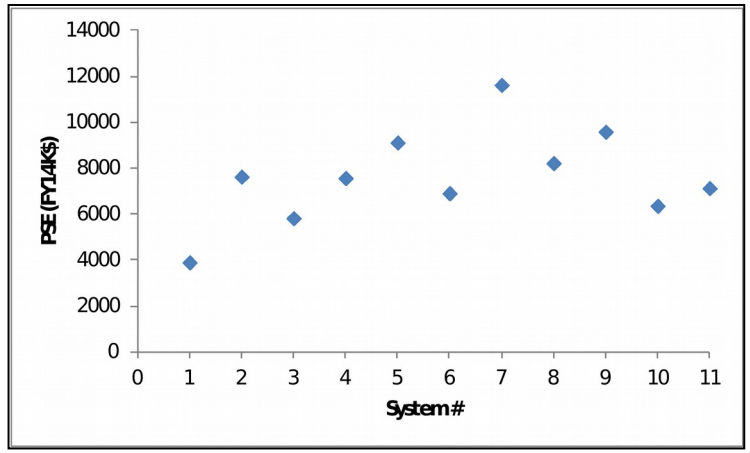
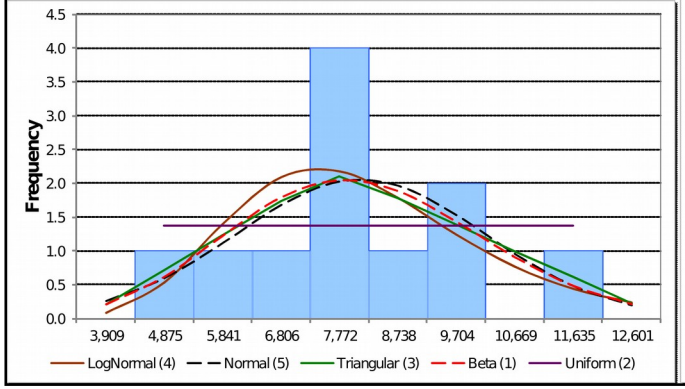


Figure 2-13

	PSE $	CDF
System #1	3909	5
System #3	5832	14
System #10	6369	23
System #6	6917	32
System #11	7142	41
System #4	7580	50
System #2	7641	59
System #8	8228	68
System #5	9128	77
System #9	9596	86
System #7	11635	95
Median	7580	



	Sample	LogNormal	Normal	Triangular	Beta	Uniform
Mean	7,634.2727	7,668.7976	7,634.2727	7,635.7767	7,642.8685	7,634.2727
StdDev	2,047.5470	2,057.5933	2,040.9037	1,969.0556	2,031.4244	1,878.8132
CV	0.2682	0.2683	0.2673	0.2579	0.2658	0.2461
Min	3,909.0000			3,047.7122	-1,206.7498	4,380.0727
Mode		6,909.4256	7,634.2727	7,195.7043	7,375.0091	
Max	11,635.0000			12,663.9137	26,548.9502	10,888.4727
Alpha					12.6081	
Beta					26.9357	
Data Count	11	% < 0 =	0.01%	None	0.00%	None
Standard Error of Estimate		371.6543	354.4826	407.5106	396.8587	616.0862
Rank		2	1	4	3	5
SEE / Fit Mean		4.85%	4.64%	5.34%	5.19%	8.07%
Chi^2 Fit test 5 Bins, Sig 0.05		Good (83%)	Good (83%)	Good (55%)	Unknown	Good (21%)



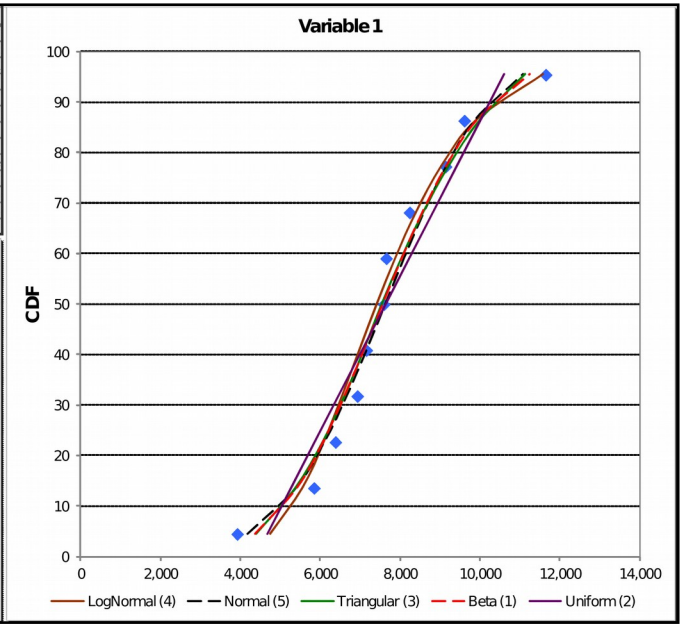
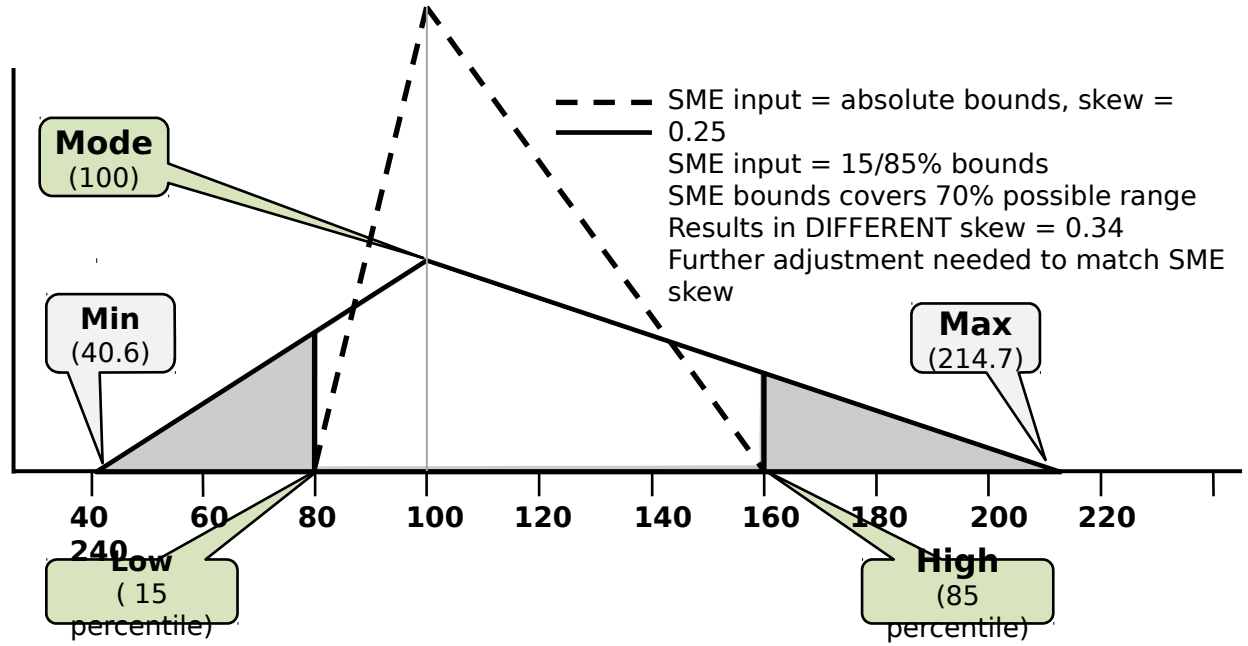
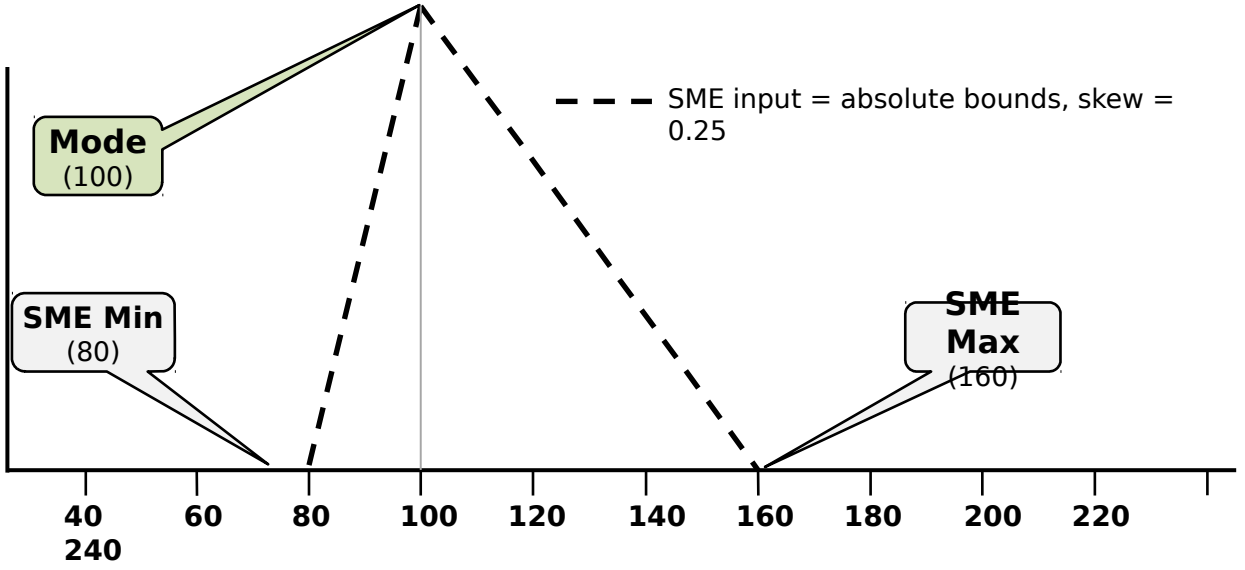


Figure 2-14


SME input = absolute bounds, skew = 0.25
SME input = 15/85% bounds
SME bounds covers 70% possible range
Results in DIFFERENT skew = 0.34
Further adjustment needed to match SME skew
Mode
(100)
Min
(40.6)
Max
(214.7)
Low
(15 percentile)
High
(85 percentile)
40
60
80
100
120
140
160
180
200
220
240


SME input = absolute bounds, skew = 0.25
Mode
(100)
SME Min
(80)
SME Max
(160)
40
60
80
100
120
140
160
180
200
220
240

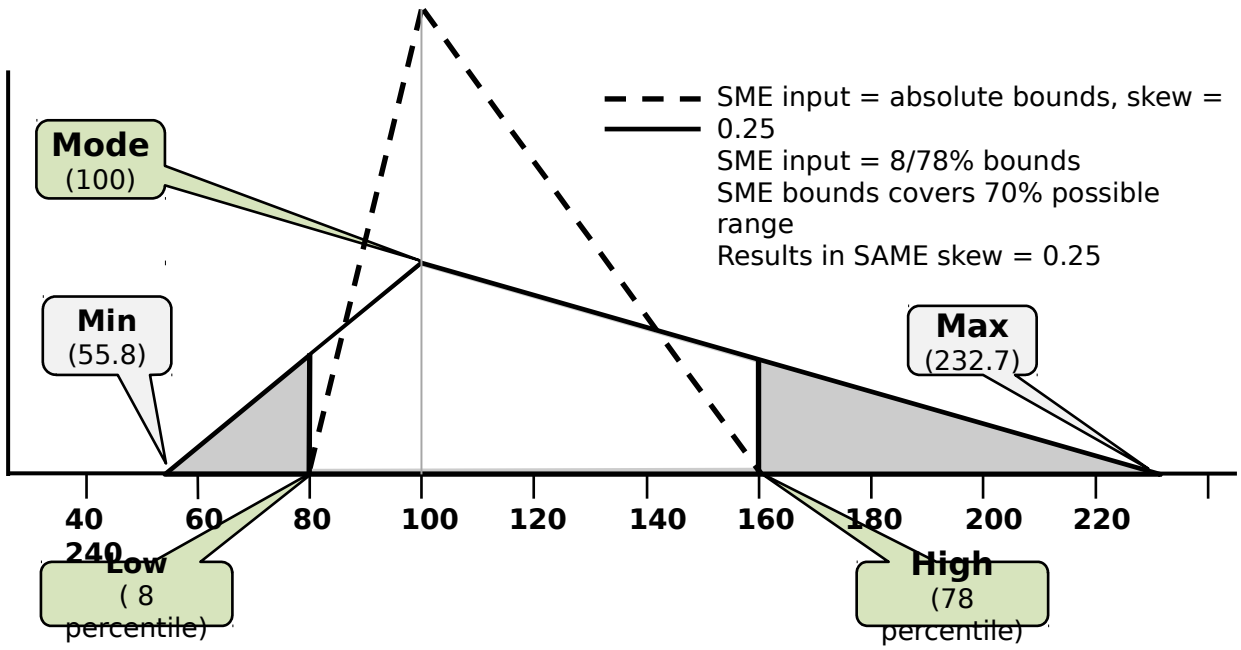

SME input = absolute bounds, skew = 0.25
SME input = 8/78% bounds
SME bounds covers 70% possible range
Results in SAME skew = 0.25
Mode
(100)
Min
(55.8)
Max
(232.7)
40
60
80
100
120
140
160
180
200
220
240
Low
(8 percentile)
High
(78 percentile)

Figure 2-16

Figure 2-17

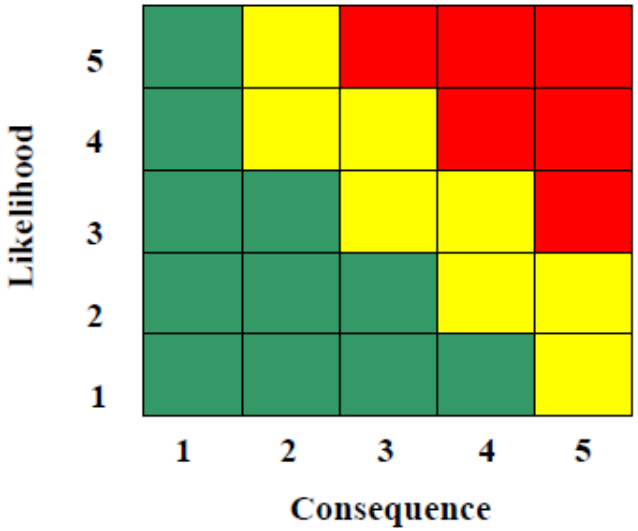


Figure 2-18

	B	C	E	F	AC	AD	AE
46	* INPUT VARIABLES	Unique ID	Point Estimate	Forecast	Distribution Form	Point Estimate is:	Uncert ainty
112	Guidance First Unit Cost	Guid_UC1	$100.00	$100.00			
113	Guidance First Unit Cost CER	Guid_UC1Raw	$100.00	$100.00	Triangular	Mode	1.00
114	Guidance RR#2 Add to First Unit Cost	GuideRR2_Add					
121							
122	* Guidance Risk Register (RR #2)						
123	Prod RR2 Potential Guidance Cost Incr	ProdRR2_GuidInc	50.0000	50.0000	LogNormal	Median	1.00
124	Prod RR2 Probability Prototype Problem	ProdRR2_GuidProb	30	30	BetaPERT	Median	
125	Prod RR2 Guidance	ProdRR2_Guid			Yes/No	N/A	

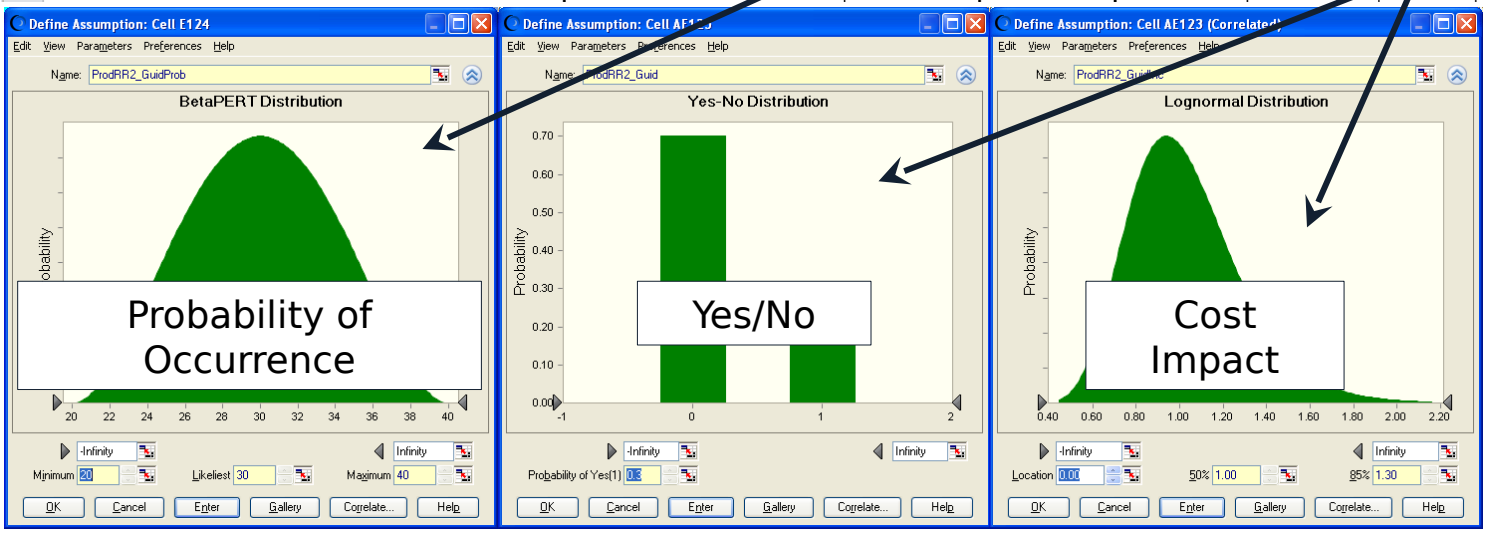


Figure 2-19

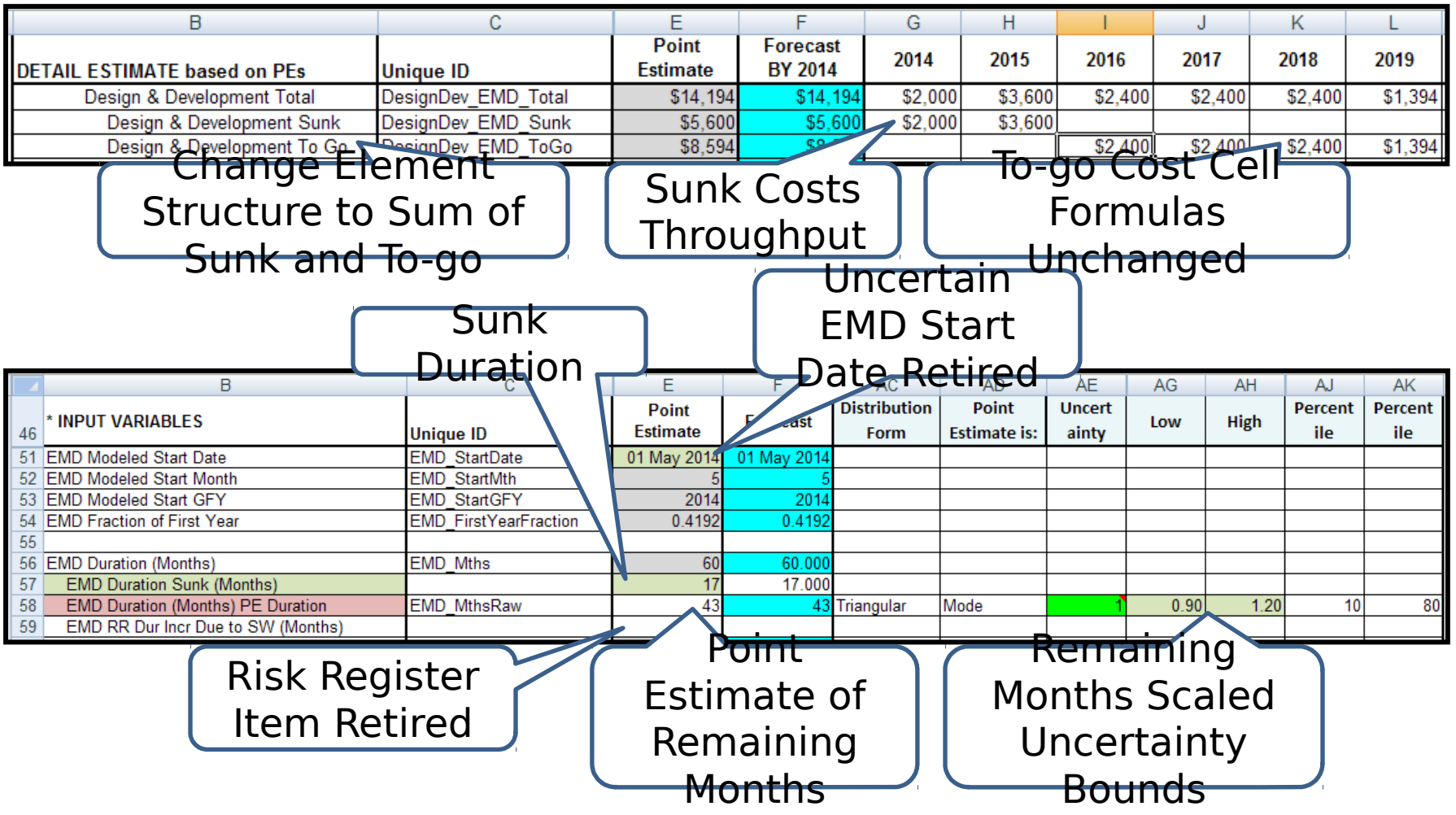

B
C
E
F
G
H
I
J
K
L
DETAIL ESTIMATE based on PEs
Unique ID
Point Estimate
Forecast BY 2014
2014
2015
2016
2017
2018
2019
Design & Development Total
DesignDev_EMD_Total
$14,194
$14,194
$2,000
$3,600
$2,400
$2,400
$2,400
$1,394
Design & Development Sunk
DesignDev_EMD_Sunk
$5,600
$5,600
$2,000
$3,600
Design & Development To Go
DesignDev_EMD_ToGo
$8,594
$2,400
$2,400
$2,400
$1,394
Change Element Structure to Sum of Sunk and To-go
Sunk Costs Throughput
To-go Cost Cell Formulas Unchanged
Sunk Duration
Uncertain EMD Start Date Retired
B
C
E
F
AC
AD
AE
AG
AH
AJ
AK
46
* INPUT VARIABLES
Unique ID
Point Estimate
Distribution Form
Point Estimate is:
Uncertainty
Low
High
Percentile
Percentile
51
EMD Modeled Start Date
EMD_StartDate
01 May 2014
01 May 2014
52
EMD Modeled Start Month
EMD_StartMth
5
5
53
EMD Modeled Start GFY
EMD_StartGFY
2014
2014
54
EMD Fraction of First Year
EMD_FirstYearFraction
0.4192
0.4192
55
56
EMD Duration (Months)
EMD_Mths
60
60.000
57
EMD Duration Sunk (Months)
17
17.000
58
EMD Duration (Months) PE Duration
EMD_MthsRaw
43
43
Triangular
Mode
1
0.90
1.20
10
80
59
EMD RR Dur Incr Due to SW (Months)
Risk Register Item Retired
Point Estimate of Remaining Months
Remaining Months Scaled Uncertainty Bounds

Figure 2-20

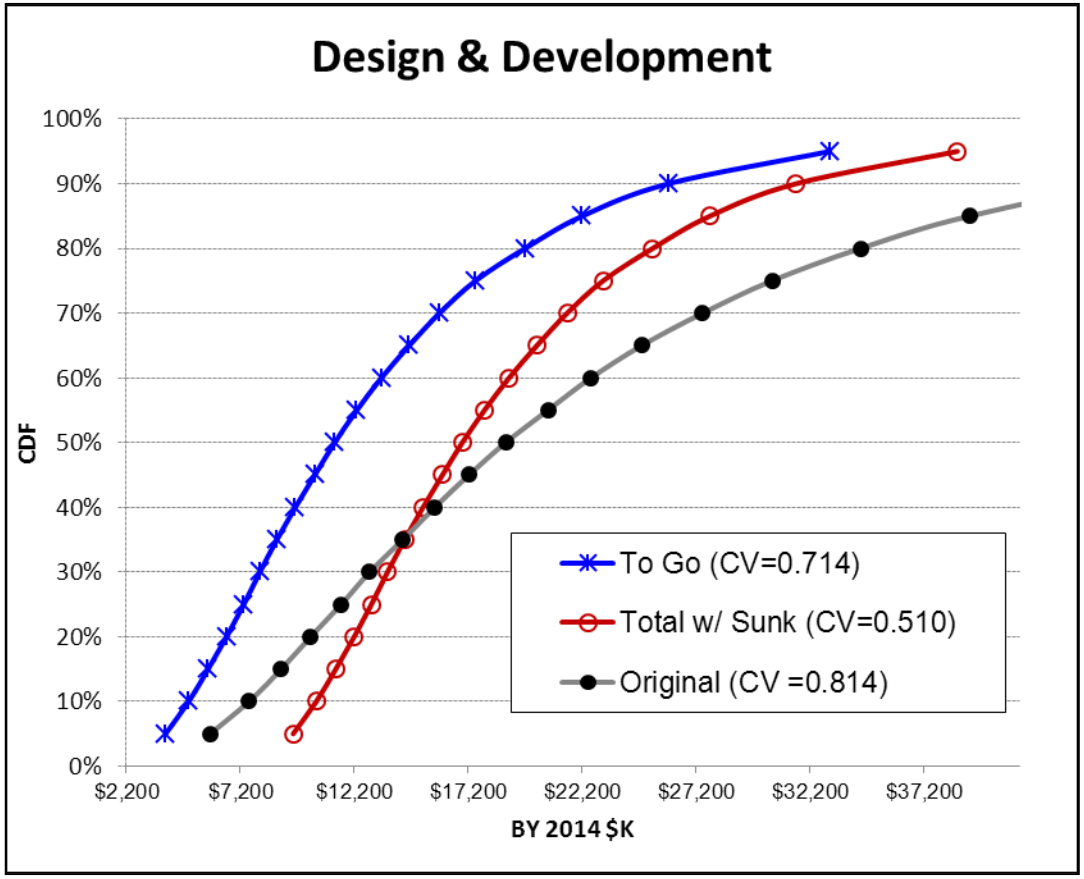
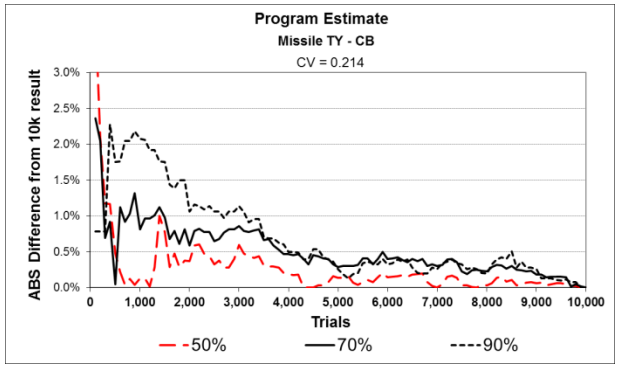
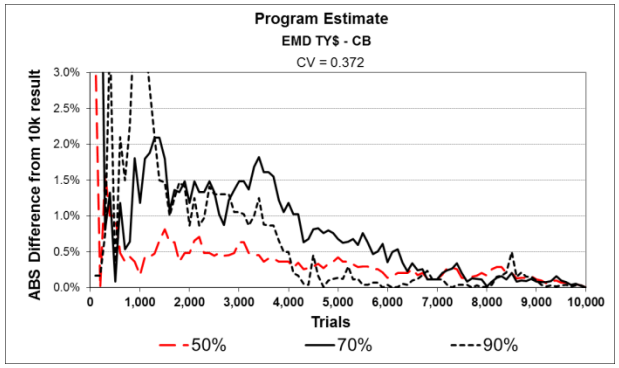
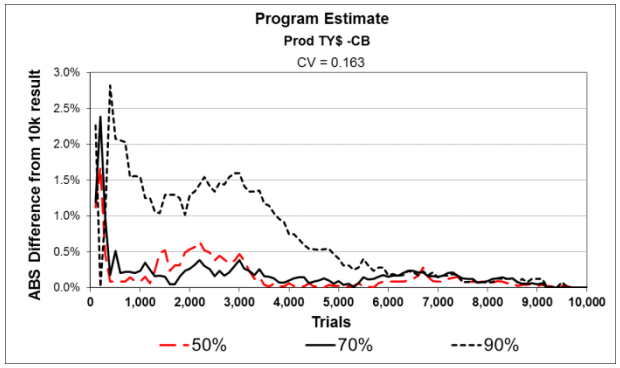
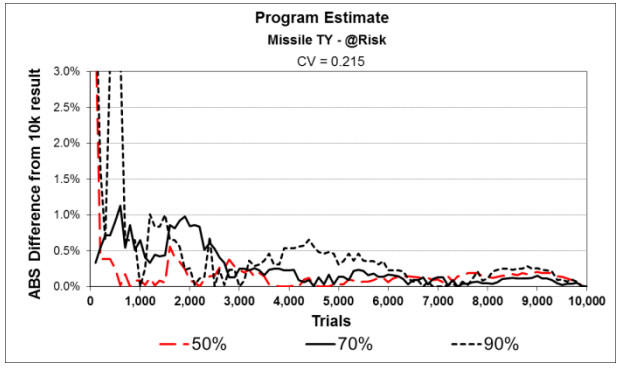

Design & Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
CDF
$2,200
$7,200
$12,200
$17,200
$22,200
$27,200
$32,200
$37,200
BY 2014 $K
To Go (CV=0.714)
Total w/ Sunk (CV=0.510)
Original (CV =0.814)

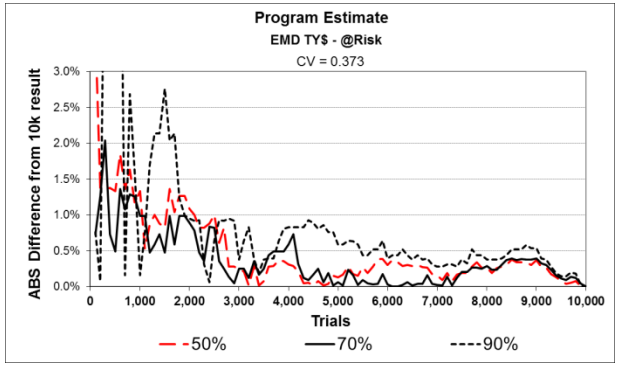
Figure 3-7

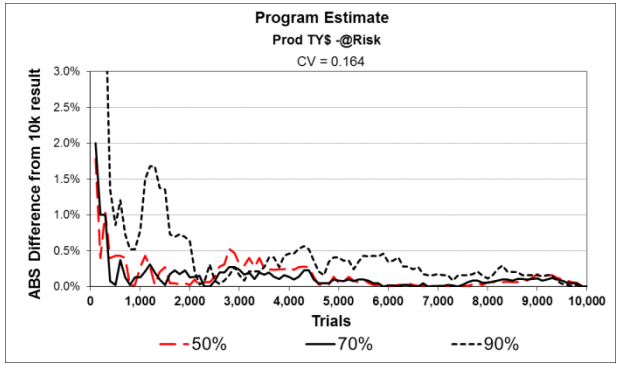

Program Estimate
Missile TY - CB
CV = 0.214
ABS Difference from 10k result
Trials
-50%
70%
90%

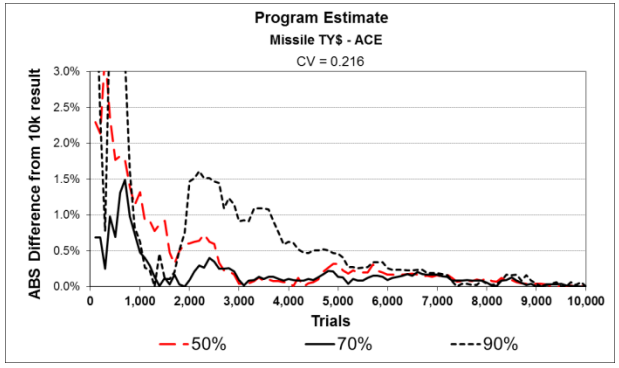

Program Estimate
EMD TY$ - CB
CV = 0.372
ABS Difference from 10k result
Trials
-50%
70%
90%

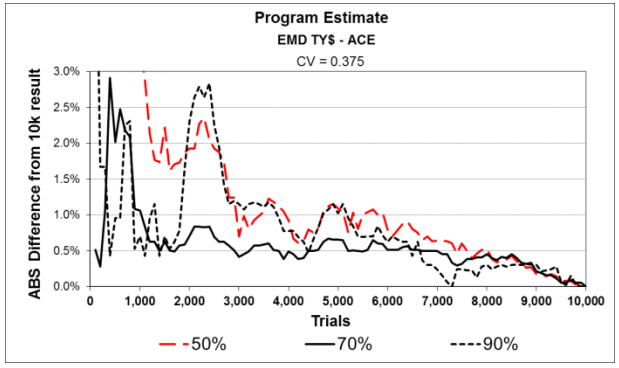

Program Estimate
Prod TY$ -CB
CV = 0.163
ABS Difference from 10k result
Trials
-50%
70%
90%

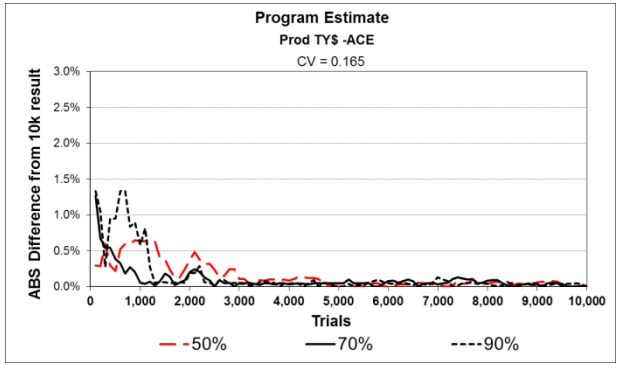

Program Estimate
Missile TY - @Risk
CV = 0.215
ABS Difference from 10k result
Trials
-50%
70%
90%


Program Estimate
EMD TY$ - @Risk
CV = 0.373
ABS Difference from 10k result
Trials
-50%
70%
90%

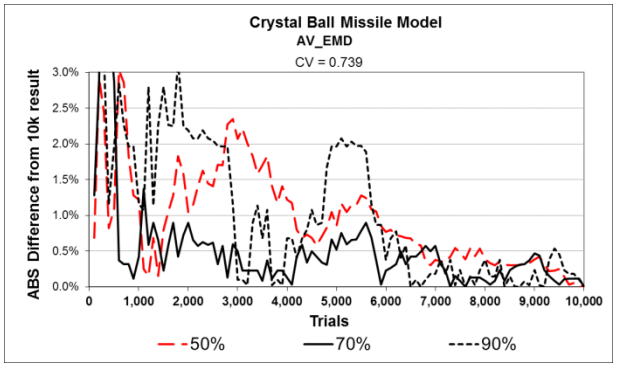

Program Estimate
Prod TY$ -@Risk
CV = 0.164
ABS Difference from 10k result
Trials
-50%
70%
90%

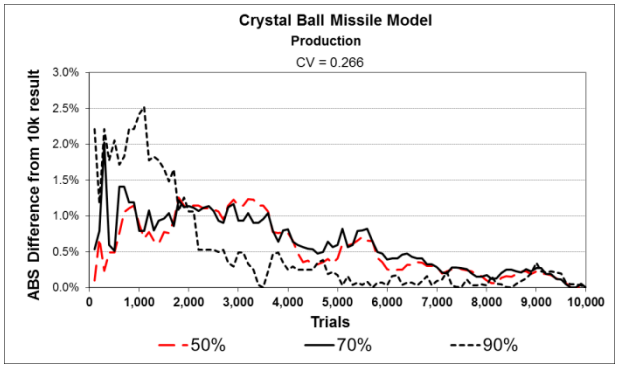

Program Estimate
Missile TY$ - ACE
CV = 0.216
ABS Difference from 10k result
Trials
-50%
70%
90%

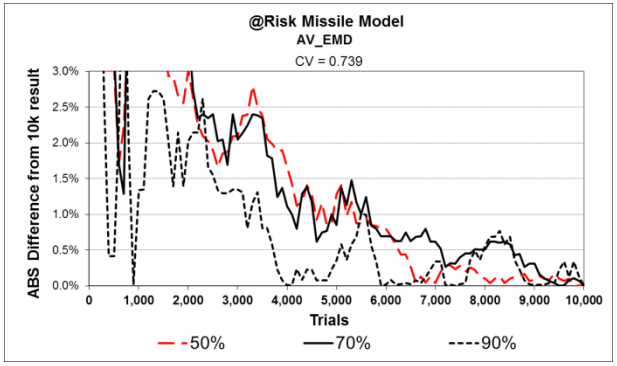

Program Estimate
EMD TY$ - ACE
CV = 0.375
ABS Difference from 10k result
Trials
-50%
70%
90%

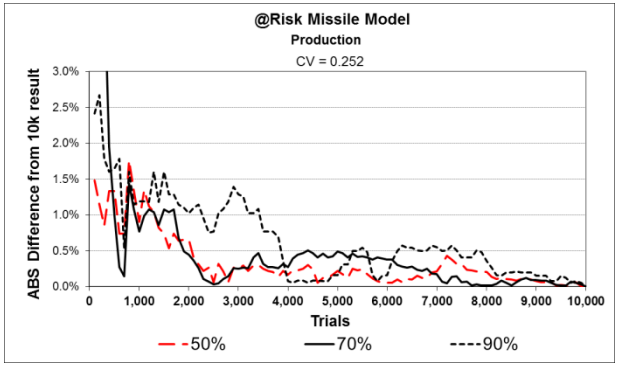

Program Estimate
Prod TY$ -ACE
CV = 0.165
ABS Difference from 10k result
Trials
-50%
70%
90%

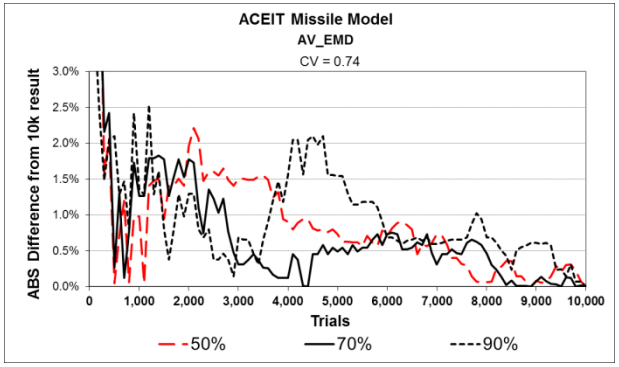
From Model before link between EMD and Prod was broken And Production Duration Uncertainty Removed











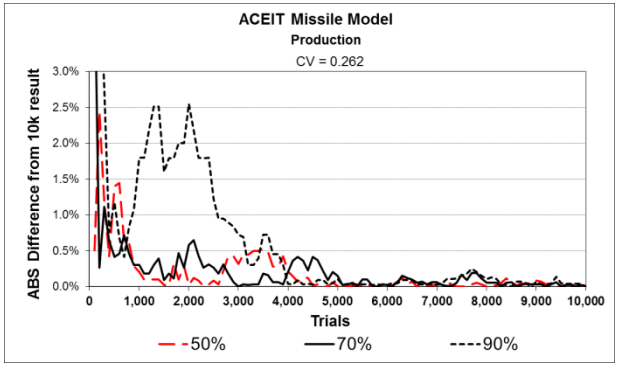
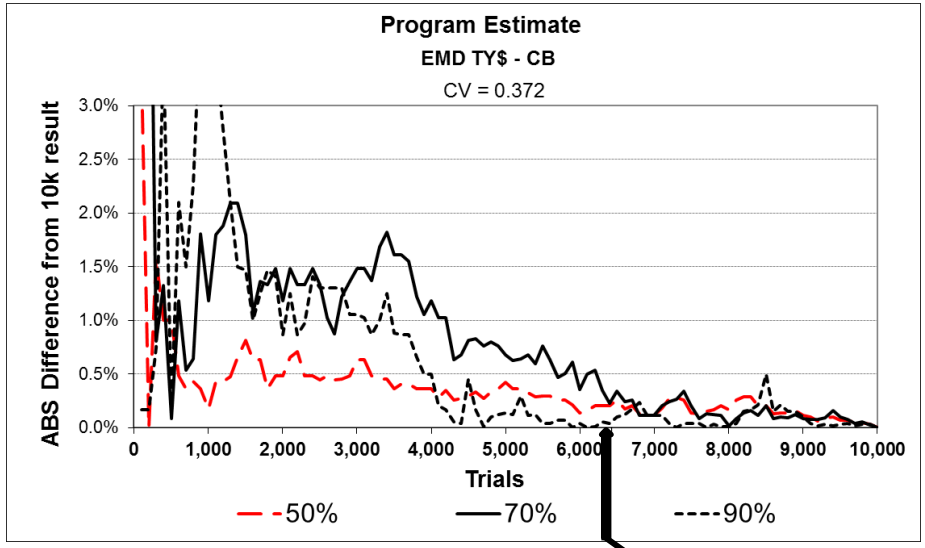
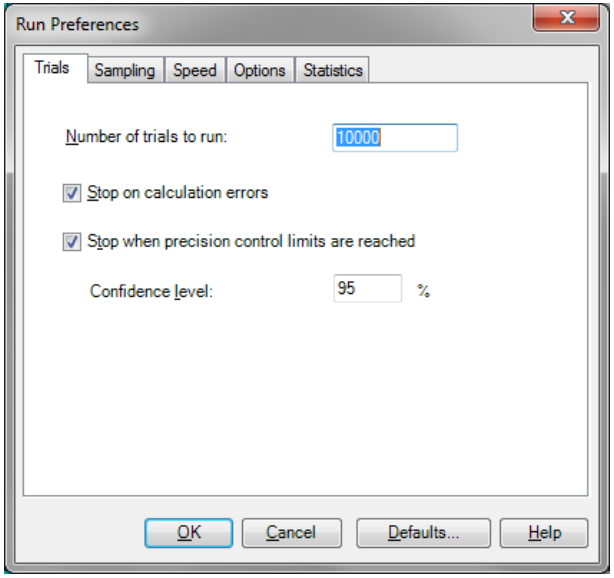
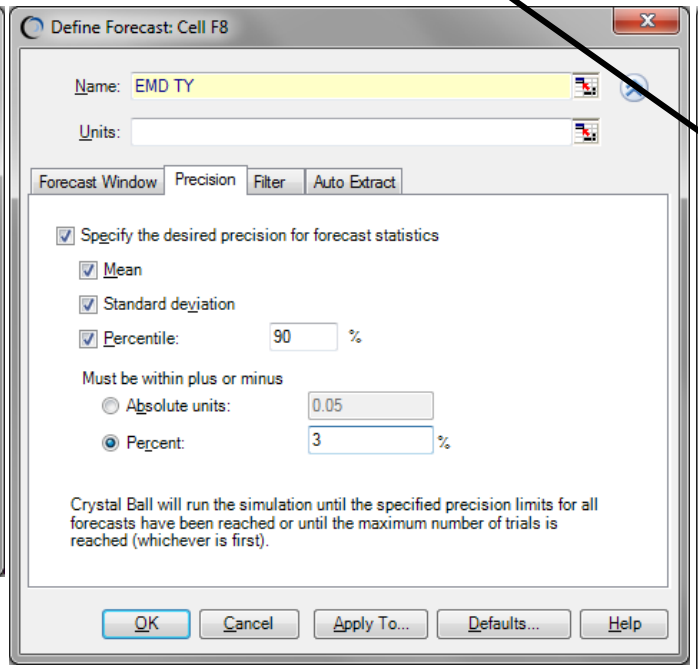


Figure 3-8


Program Estimate
EMD TY$ - CB
CV = 0.372
ABS Difference from 10k result
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Trials
50%
70%
90%


Run Preferences
Trials
Sampling
Speed
Options
Statistics
Number of trials to run:
10000
Stop on calculation errors
Stop when precision control limits are reached
Confidence level:
95
%
OK
Cancel
Defults...
Help


Define Forecast: Cell F8
Name:
EMD TY
Units:
Forecast Window
Precision
Filter
Auto Extract
Specify the desired precision for forecast statistics
Mean
Standard deviation
Percentile:
90
%
Must be within plus or minus
Absolute units:
0.05
Percent:
3
%
Crystal Ball will run the simulation until the specified precision limits for all forecasts have been reached or until the maximum number of trials is reached (whichever is first).
OK
Cancel
Apply To...
Defaults...
Help

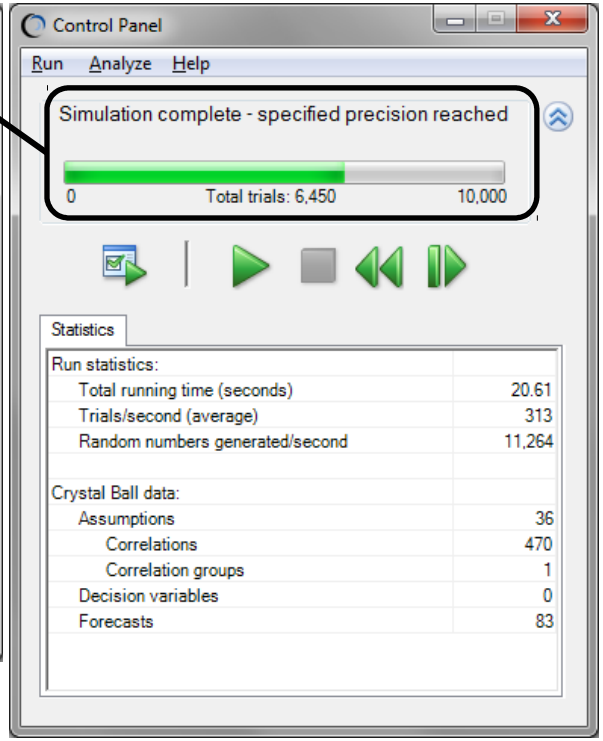

Control Panel
Run
Analyze
Help
Simulation complete - specified precision reached
0
Total trials: 6,450
10,000
Statistics
Run statistics:
Total running time (seconds) 20.61
Trials/second (average) 313
Random numbers generated/second 11,264
Crystal Ball data:
Assumptions 36
Correlations 470
Correlation groups 1
Decision variables 0
Forecasts 83

Figure 3-11

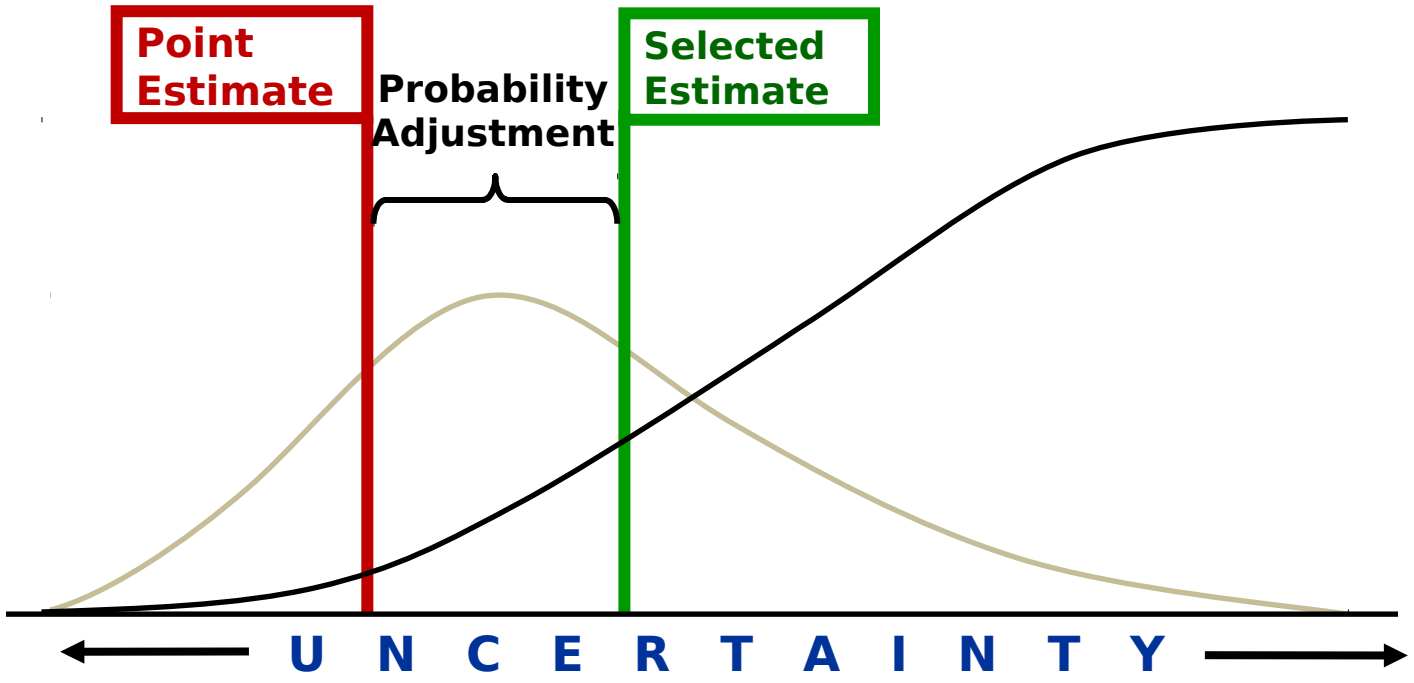

Point Estimate
Probability Adjustment
Selected Estimate
U N C E R T A I N T Y

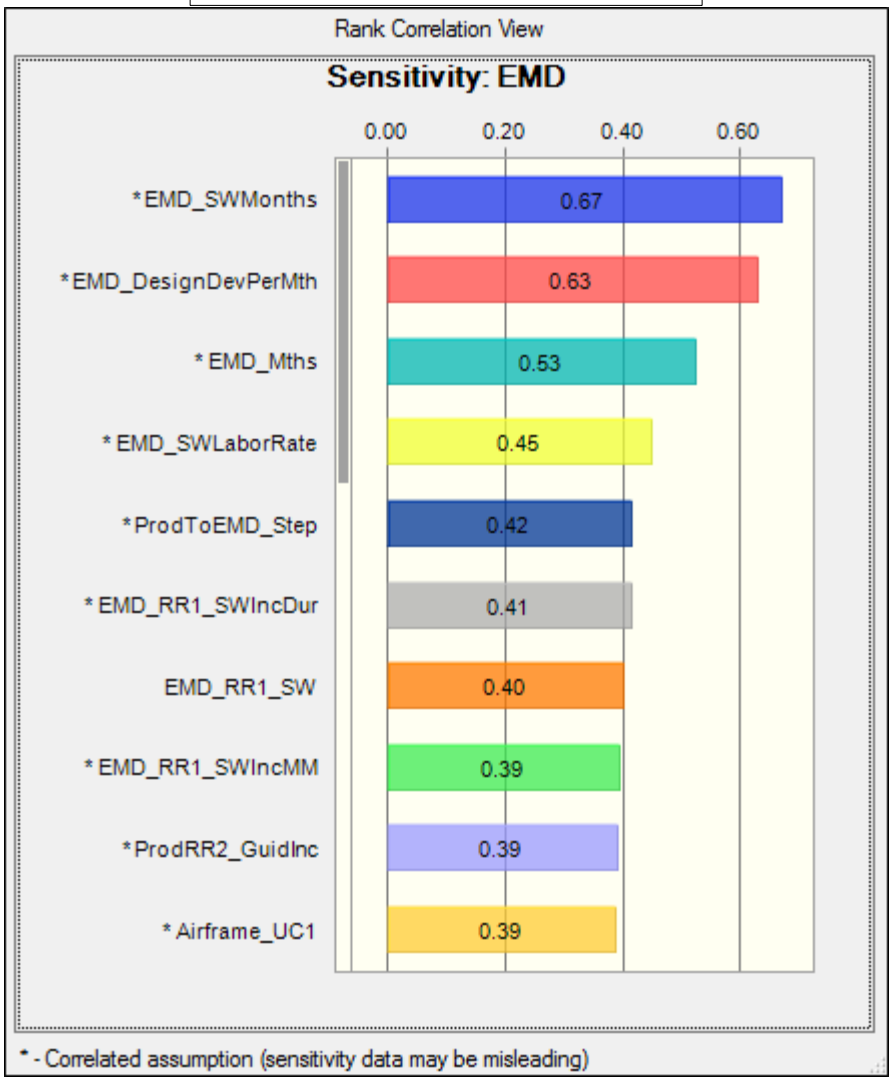
Figure 3-12

Need^2 Adjusted for Correlation = Need*MMULT(CorrRow, EMD Need)

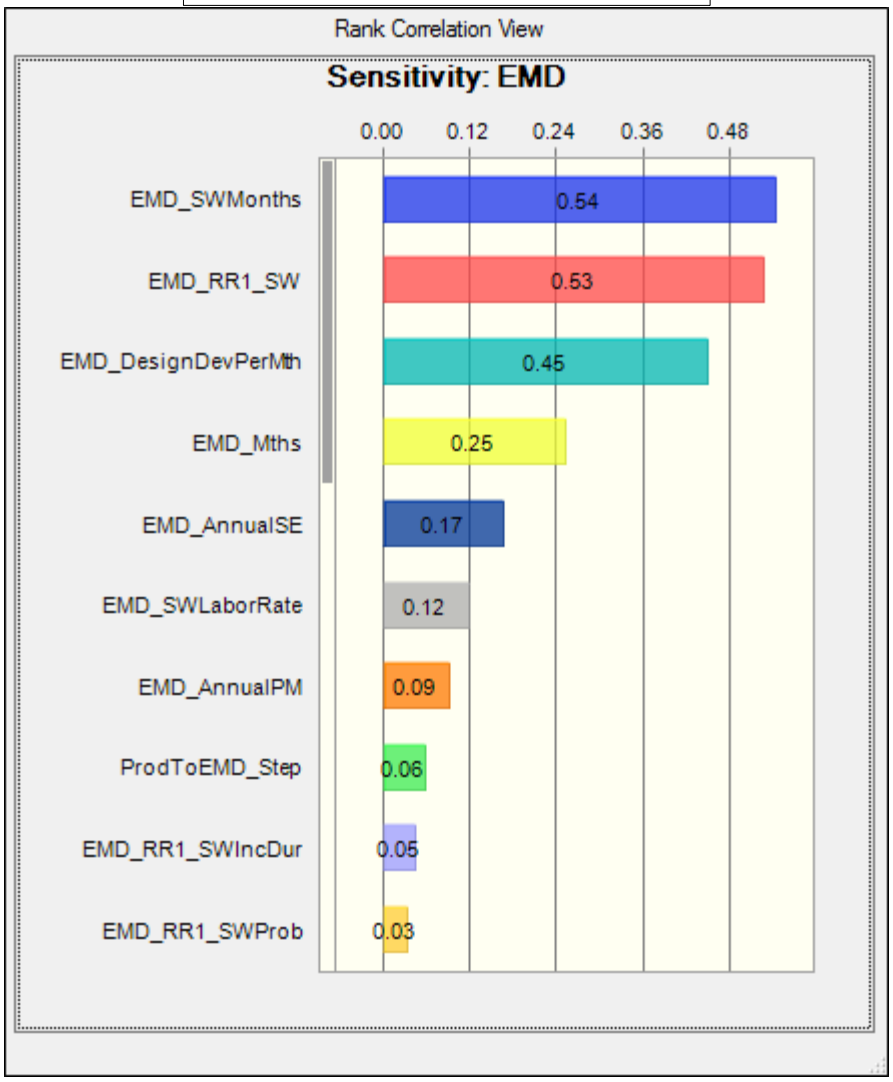
Calculate and Adjust Need For Correlation	Point Estimate	85% Result	Need Unadjusted	Need^2 Adj For Corr
Missile System	$246,836	$393,263		
Engineering and Manufacturing D	$83,539	$175,643	$92,104	$5,478,432,524
Air Vehicle	$14,944	$44,271	$29,327	$1,649,681,403
Design & Development	$12,000	$39,226	$27,226	$1,530,361,494
Prototypes	$2,944	$5,822	$2,877	$119,319,909
Software	$31,500	$66,192	$34,692	$2,010,072,404
System Engineering	$17,500	$35,481	$17,981	$818,016,531
Program Management	$15,000	$26,045	$11,045	$511,171,578
System Test and Evaluation	$1,767	$5,281	$3,514	$132,107,590
Training	$897	$3,145	$2,249	$128,973,713
Data	$1,196	$4,231	$3,035	$174,402,151
Peculiar Support Equipment	$736	$2,208	$1,472	$54,007,154

	EMD									
EMD	AV	Des & Dev	Proto	SW	Sys Eng	PM	STE	Trg	Data	PSE
1.000	0.806	0.792	0.561	0.799	0.546	0.572	0.491	0.801	0.802	0.480
0.806	1.000	0.998	0.485	0.385	0.273	0.323	0.378	0.970	0.970	0.363
0.792	0.99	1.000	0.425	0.365	0.269	0.318	0.331	0.967	0.968	0.316
0.561	0.485	0.425	1.000	0.437	0.178	0.207	0.774	0.474	0.472	0.771
0.799	0.385	0.365	0.437	1.000	0.272	0.314	0.339	0.379	0.378	0.345
0.546	0.273	0.269	0.178	0.272	1.000	0.660	0.268	0.306	0.308	0.267
0.572	0.323	0.318	0.207	0.314	0.660	1.000	0.274	0.348	0.352	0.274
0.491	0.378	0.331	0.774	0.339	0.268	0.274	1.000	0.407	0.409	0.717
0.801	0.970	0.967	0.474	0.379	0.306	0.348	0.407	1.000	0.959	0.388
0.802	0.970	0.968	0.472	0.378	0.308	0.352	0.409	0.959	1.000	0.391
0.480	0.363	0.316	0.771	0.345	0.267	0.274	0.717	0.388	0.391	1.000

Correlation Enabled

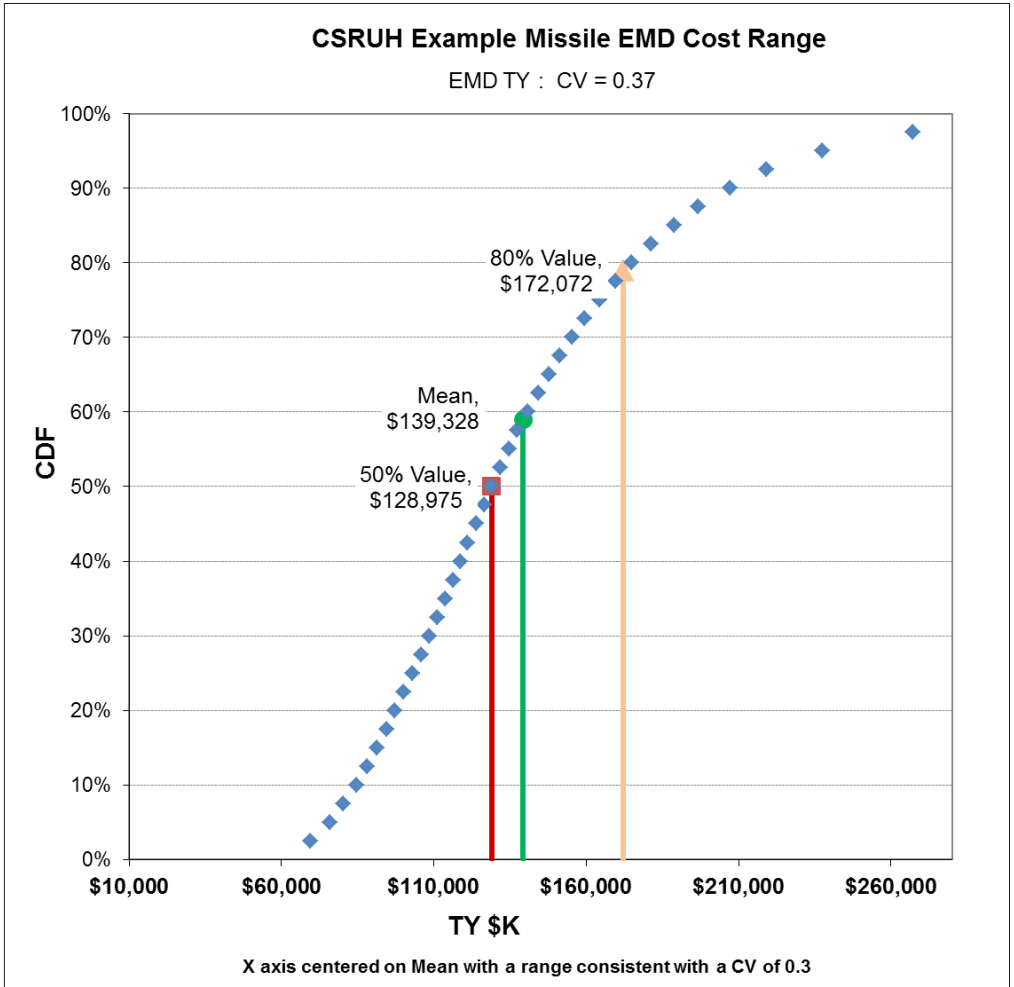


Correlation Disabled



obtained from the S-Curve Utility and the "PA Dollar Allocation - Std Dev" sheet in the CB model

Figure 4-8



Probability	TY K$
90%	$207,255
80%	$172,072
70%	$155,334
60%	$140,795
50%	$128,975
40%	$118,768
30%	$108,375
20%	$97,122
10%	$84,554

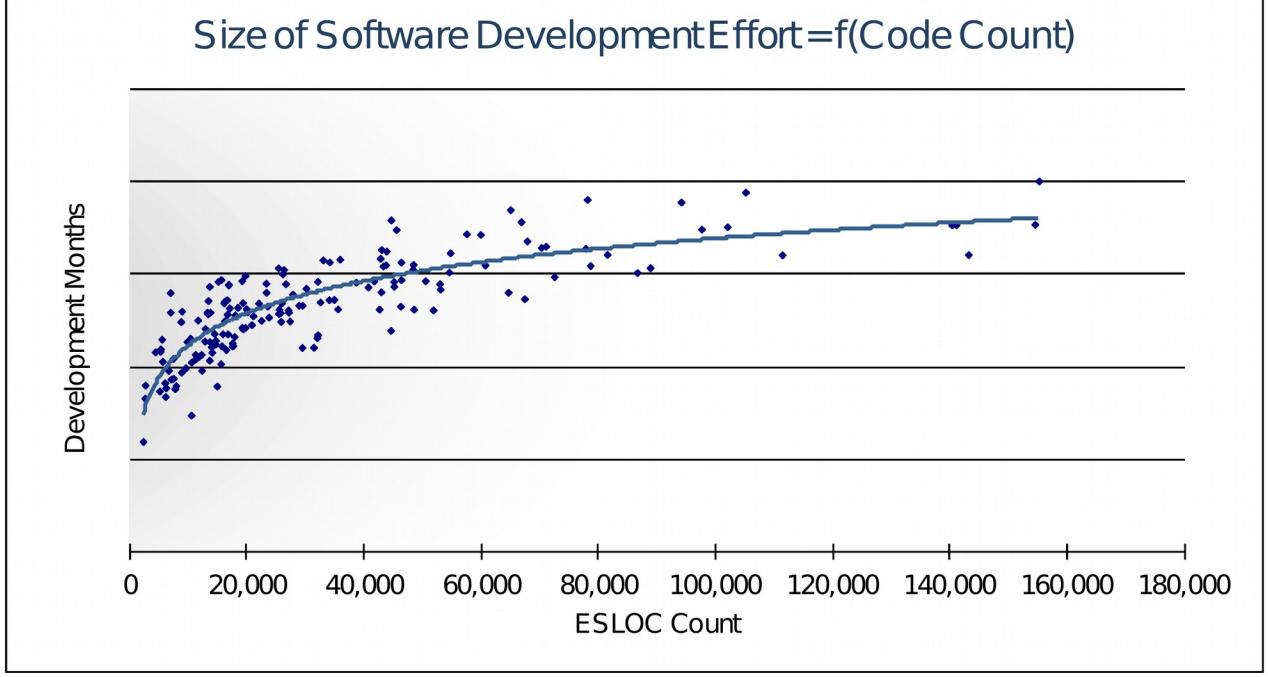
Cost Uncertainty Drivers

- SW Months
- Design Cost/Mth
- SW labor Rate
- EMD Duration

Figure 4-9

80% TY $K Allocated From EMD and Production.	Risk Dollars are Phased Across the Point Estimate Schedule									
	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022
Missile System	$421,268	$26,682	$32,608	$34,455	$38,084	$34,393	$59,857	$66,456	$64,629	$64,106
Engineering and Manufacturing Development	$172,072	$26,682	$32,608	$34,455	$38,084	$34,393	$5,851			
Production & Deployment	$253,022						$54,831	$67,475	$65,622	$65,093

Fig 5-2


Size of Software Development Effort = f(Code Count)
Development Months
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
ESLOC Count

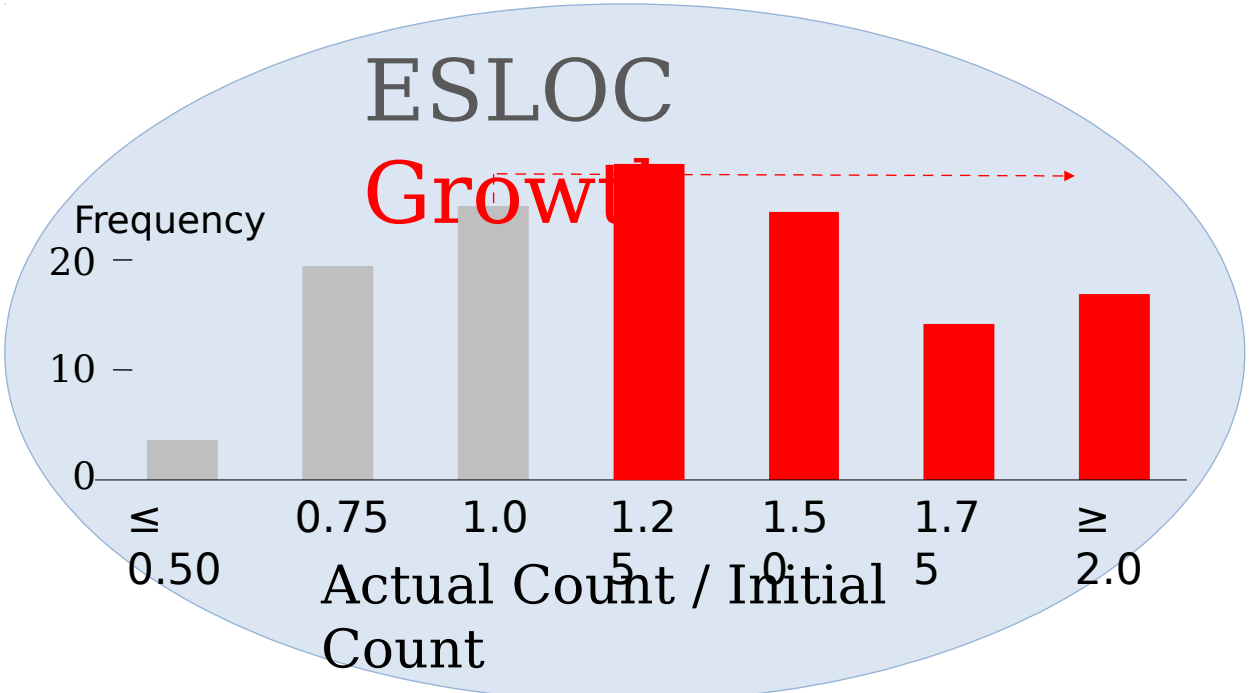
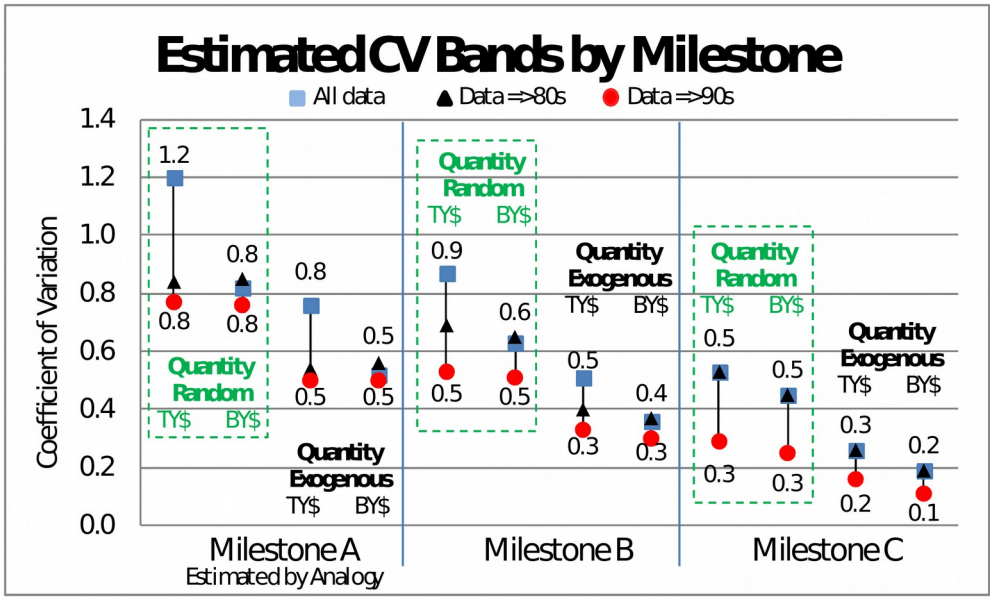

ESLOC
Growth
Frequency
20
10
0
≤ 0.50
0.75
1.0
1.25
1.50
1.75
≥ 2.0
Actual Count / Initial Count

Fig 5-4


Estimated CV Bands by Milestone
All data
Data =>80s
Data =>90s
Coefficient of Variation
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Quantity Random
TY$ BY$
1.2
0.8
0.8
0.8
Quantity Exogenous
TY$ BY$
0.8
0.5
0.5
Quantity Random
TY$ BY$
0.9
0.6
0.5
0.5
Quantity Exogenous
TY$ BY$
0.5
0.4
0.3
0.3
Quantity Random
TY$ BY$
0.5
0.5
0.3
0.3
Quantity Exogenous
TY$ BY$
0.3
0.2
0.2
0.1
Milestone A
Estimated by Analogy
Milestone B
Milestone C

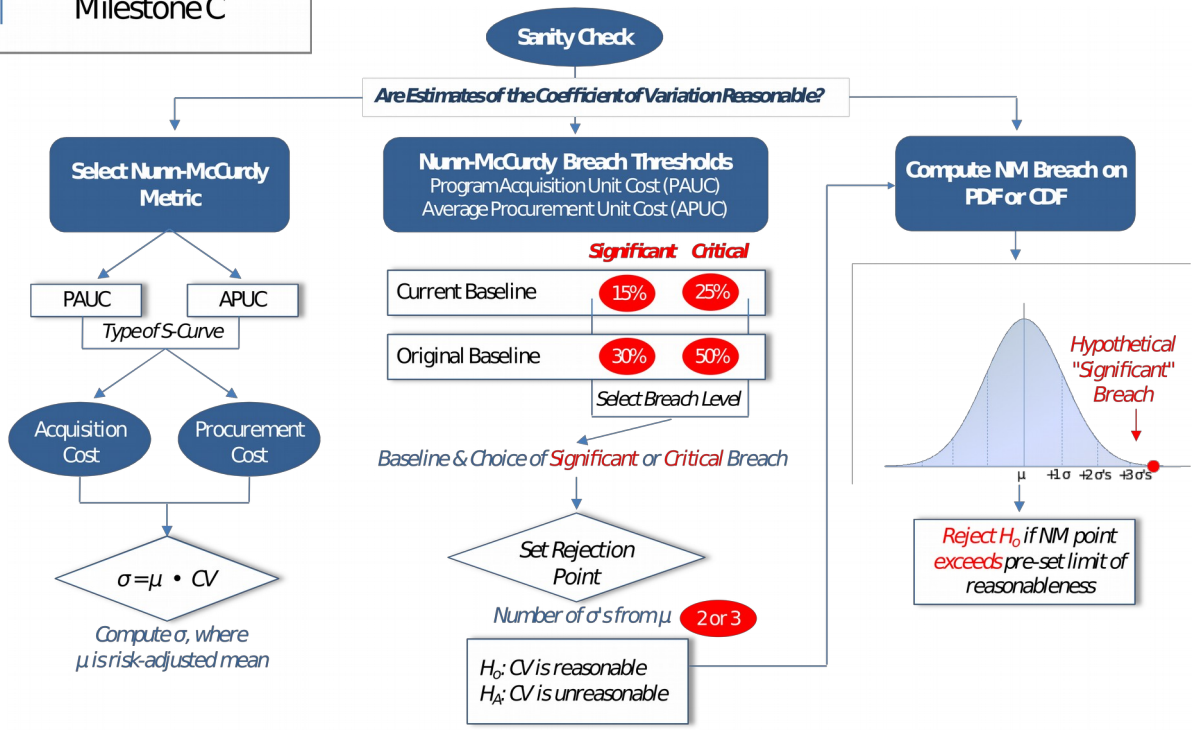

Sanity Check
Are Estimates of the Coefficient of Variation Reasonable?
Select Nunn-McCurdy Metric
PAUC
APUC
Type of S-Curve
Acquisition Cost
Procurement Cost
σ = μ • CV
Compute σ, where μ is risk-adjusted mean
Nunn-McCurdy Breach Thresholds
Program Acquisition Unit Cost (PAUC)
Average Procurement Unit Cost (APUC)
Significant
Critical
Current Baseline
15%
25%
Original Baseline
30%
50%
Select Breach Level
Baseline & Choice of Significant or Critical Breach
Set Rejection Point
Number of σ's from μ
2 or 3
H0: CV is reasonable
HA: CV is unreasonable
Compute NM Breach on PDF or CDF
Hypothetical "Significant" Breach
μ
+1σ
+2σ's
+3σ's
Reject H0 if NM point exceeds pre-set limit of reasonableness

Figure A-10
Also Excel Graphics Fig A-10

Alternative Ways to Define a Lognormal Distribution

Uncertainty Estimating Method	PE	Eq / Thruput	Dist	PE Pos	DF	Adj SE	High %	High Interpretation
Propulsion First Unit Cost (PI)	$ 78.565 (50%)	1.618 * 290 ^ 0.6848	Log-t	Median	8		123.01 A	90.00
Propulsion First Unit Cost (Adj SE)	$ 78.565 (50%)	1.618 * 290 ^ 0.6848	Log-t	Median	8	0.1790	E	
Propulsion First Unit Cost (SE)	$ 78.565 (50%)	1.618 * 290 ^ 0.6848	Log-t	Median	8	0.1413	B	

Alternative Results

Uncertainty Estimating Method	Point Estimate	Mean	C Std Dev	CV	5.0% Level	25.0% Level	50.0% Level	75.0% Level	D 95.0% Level
Propulsion First Unit Cost (PI)	$ 78.565 (50%)	$79.733	$13.947	0.175	$59.634	$70.753	$78.566	$87.238	$103.513
Propulsion First Unit Cost (Adj SE)	$ 78.565 (50%)	$79.843	$14.630	0.183	$58.894	$70.416	$78.564	$87.659	$104.808
Propulsion First Unit Cost (SE)	$ 78.565 (50%)	$79.358	$11.382	0.143	$62.578	$72.060	$78.564	$85.659	$98.646

Mann-Wald/2 and 5% significant level version	$2\left\lfloor \frac{2n^2}{(\Phi^{-1}(\alpha))^2} \right\rfloor^{0.2}$ $5\%\ sig\ level = 1.88n^{0.4}$ ROUND(4*(2*ObsCount^2/(NORMSINV(ChiSigLvl))^2)^0.2,0)
Sturges (performs poorly for n<30)	$1+\log_2(n) \cong 1+3.322\log_{10}(n) \cong 1+1.443\ln(n)$
Scott's Choice	$\frac{\sqrt[3]{n}(\max - \min)}{3.5s}$ ROUNDUP((n^(1/3)*SampleRange)/(3.5*Stdev(Sample)),0)
Freedman-Diaconis	$\frac{\sqrt[3]{n}(\max - \min)}{2IQR}$ ROUNDUP((n^(1/3)*SampleRange)/(2*SampleInnerQuad),0)
Square Root choice	$\sqrt{n}$

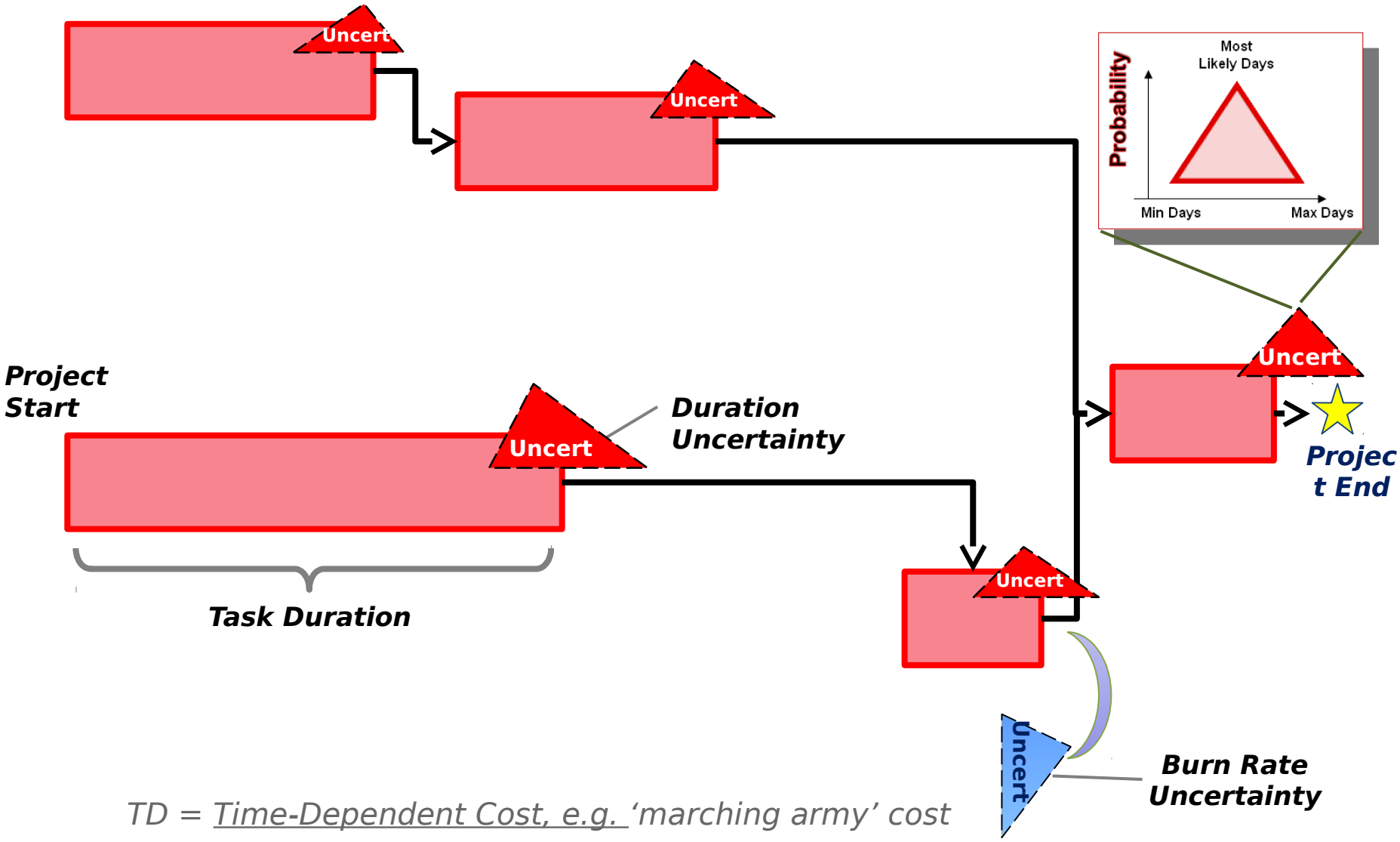
Figure A-13

Need^2 Adjusted for Correlation = Need*MMULT(CorrRow, EMD Need)

Calculate and Adjust Std Dev For Correlation	Std Dev Reported	Std Dev Adj For Corr	Variation Adj For Corr
Missile System	$69,883		
Engineering and Manufacturing D	$46,974	$46,974	$2,206,594,963
Air Vehicle	$20,493	$27,862	$776,302,671
Design & Development	$19,800	$27,134	$736,251,907
Prototypes	$1,520	$6,329	$40,050,764
Software	$23,532	$29,723	$883,431,894
System Engineering	$8,324	$14,611	$213,482,727
Program Management	$5,480	$12,132	$147,180,502
System Test and Evaluation	$1,684	$6,231	$38,829,821
Training	$1,503	$7,518	$56,527,069
Data	$1,997	$8,673	$75,220,490
Peculiar Support Equipment	$693	$3,952	$15,619,790

	EMD										
	EMD	AV	Des & Dev	Proto	SW	Sys Eng	PM	STE	Trg	Data	PSE
EMD	1.000	0.806	0.792	0.561	0.799	0.546	0.572	0.491	0.801	0.802	0.480
AV	0.806	1.000	0.998	0.485	0.385	0.273	0.323	0.378	0.970	0.970	0.363
Des & Dev	0.792	0.998	1.000	0.425	0.365	0.269	0.318	0.331	0.967	0.968	0.316
Proto	0.561	0.485	0.425	1.000	0.437	0.178	0.207	0.774	0.474	0.472	0.771
SW	0.799	0.385	0.365	0.437	1.000	0.272	0.314	0.339	0.379	0.378	0.345
Sys Eng	0.546	0.273	0.269	0.178	0.272	1.000	0.660	0.268	0.306	0.308	0.267
PM	0.572	0.323	0.318	0.207	0.314	0.660	1.000	0.274	0.348	0.352	0.274
STE	0.491	0.378	0.331	0.774	0.339	0.268	0.274	1.000	0.407	0.409	0.717
Trg	0.801	0.970	0.967	0.474	0.379	0.306	0.348	0.407	1.000	0.959	0.388
Data	0.802	0.970	0.968	0.472	0.378	0.308	0.352	0.409	0.959	1.000	0.391
PSE	0.480	0.363	0.316	0.771	0.345	0.267	0.274	0.717	0.388	0.391	1.000

Fig B-1



TD = Time-Dependent Cost, e.g. 'marching army' cost

Fig B-2

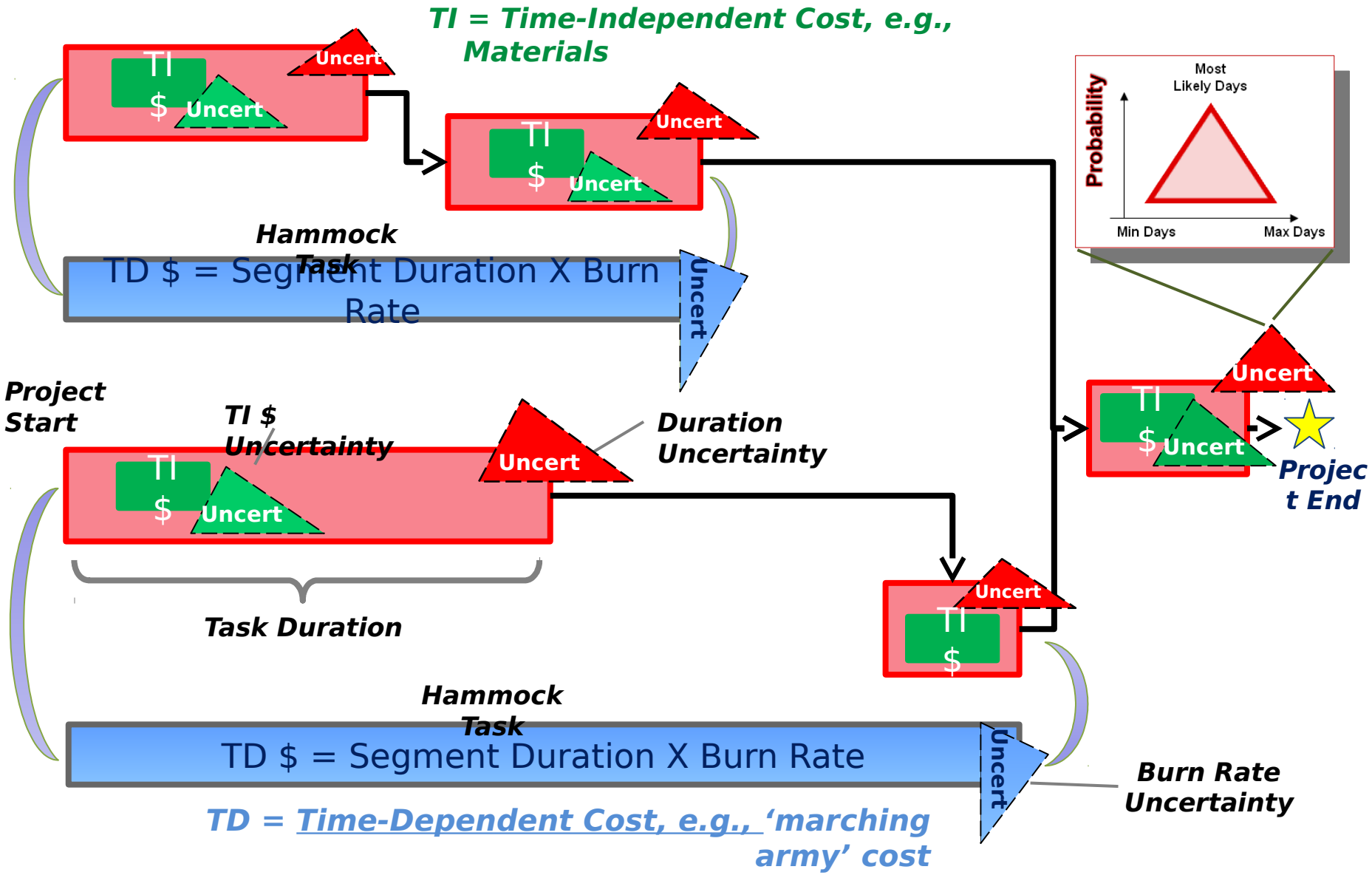

TI = Time-Independent Cost, e.g., Materials
TI
$
Uncert
Uncert
TI
$
Uncert
Uncert
Most Likely Days
Probability
Min Days
Max Days
Hammock Task
TD $ = Segment Duration X Burn Rate
Uncert
Project Start
TI $ Uncertainty
TI
$
Uncert
Uncert
Duration Uncertainty
Uncert
TI
$
Uncert
Uncert
TI
$
Uncert
Project End
Task Duration
Hammock Task
TD $ = Segment Duration X Burn Rate
Uncert
Burn Rate Uncertainty
TD = Time-Dependent Cost, e.g., 'marching army' cost

Fig B-3

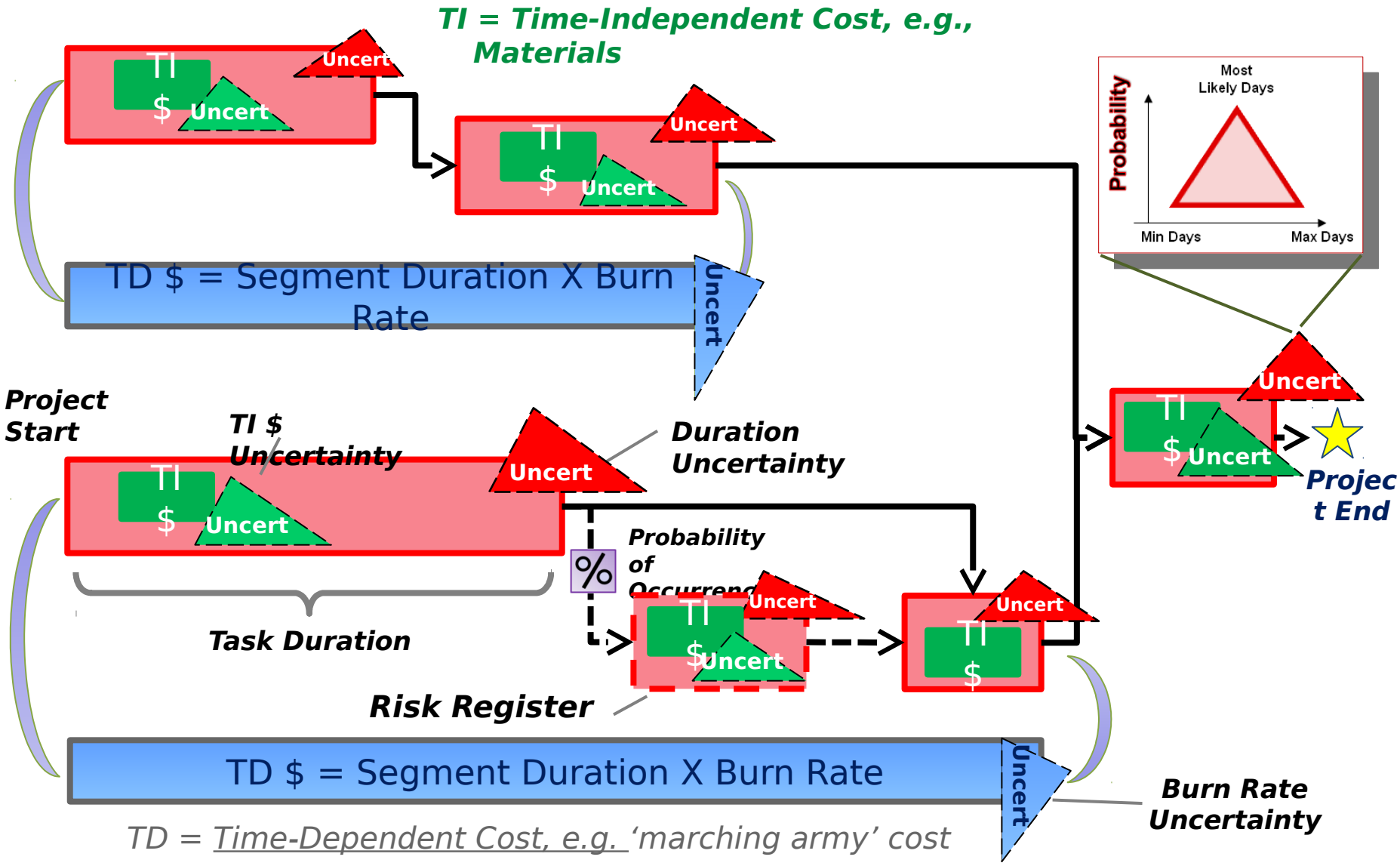
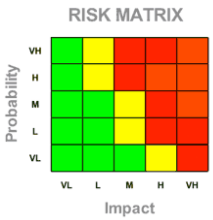

TI = Time-Independent Cost, e.g., Materials
TI
$
Uncert
Most Likely Days
Probability
Min Days
Max Days
TD $ = Segment Duration X Burn Rate
Project Start
TI $ Uncertainty
Duration Uncertainty
Task Duration
%
Probability of Occurrence
Risk Register
Project End
TD $ = Segment Duration X Burn Rate
Burn Rate Uncertainty
TD = Time-Dependent Cost, e.g. 'marching army' cost

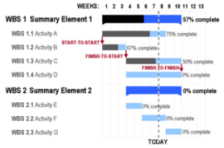
Figure B-4

The FIC/SM Process

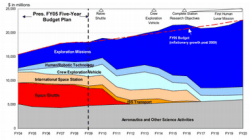
Risk



Schedul
e



Cost



Collect Risk Data

Assign Likelihood, Estimate Impact

Map to Schedule Activities

Assess Event Cost and Duration Uncertainty

Collect Schedule Data

Create Analysis Schedule

Update Analysis Schedule

Assess Duration Uncertainty

Collect Cost Data

Identify as TD or TI

Map to Schedule Activities

Assess Cost Uncertainty

Apply Correlation

Validate File

Run Analysis

Figure B-6

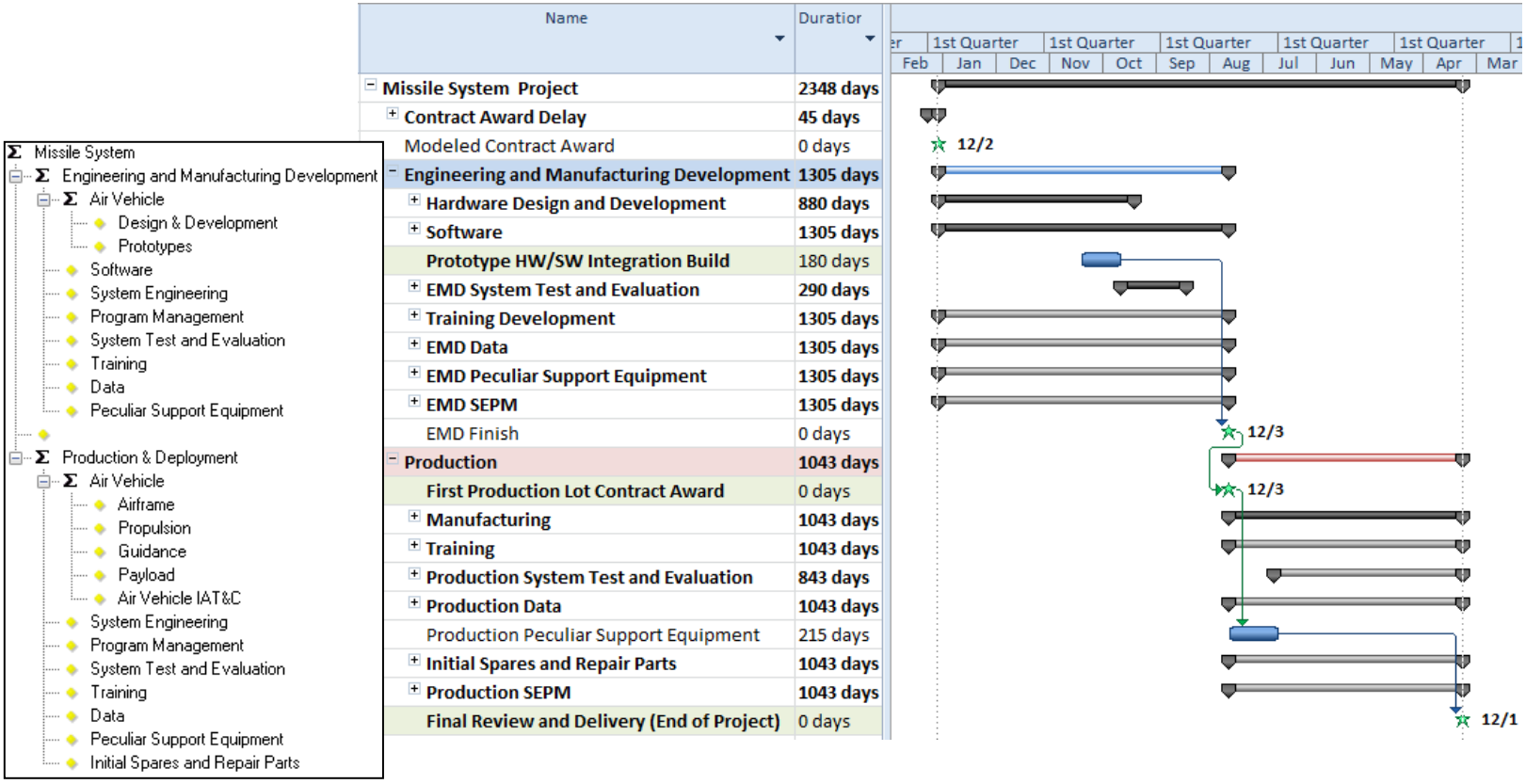
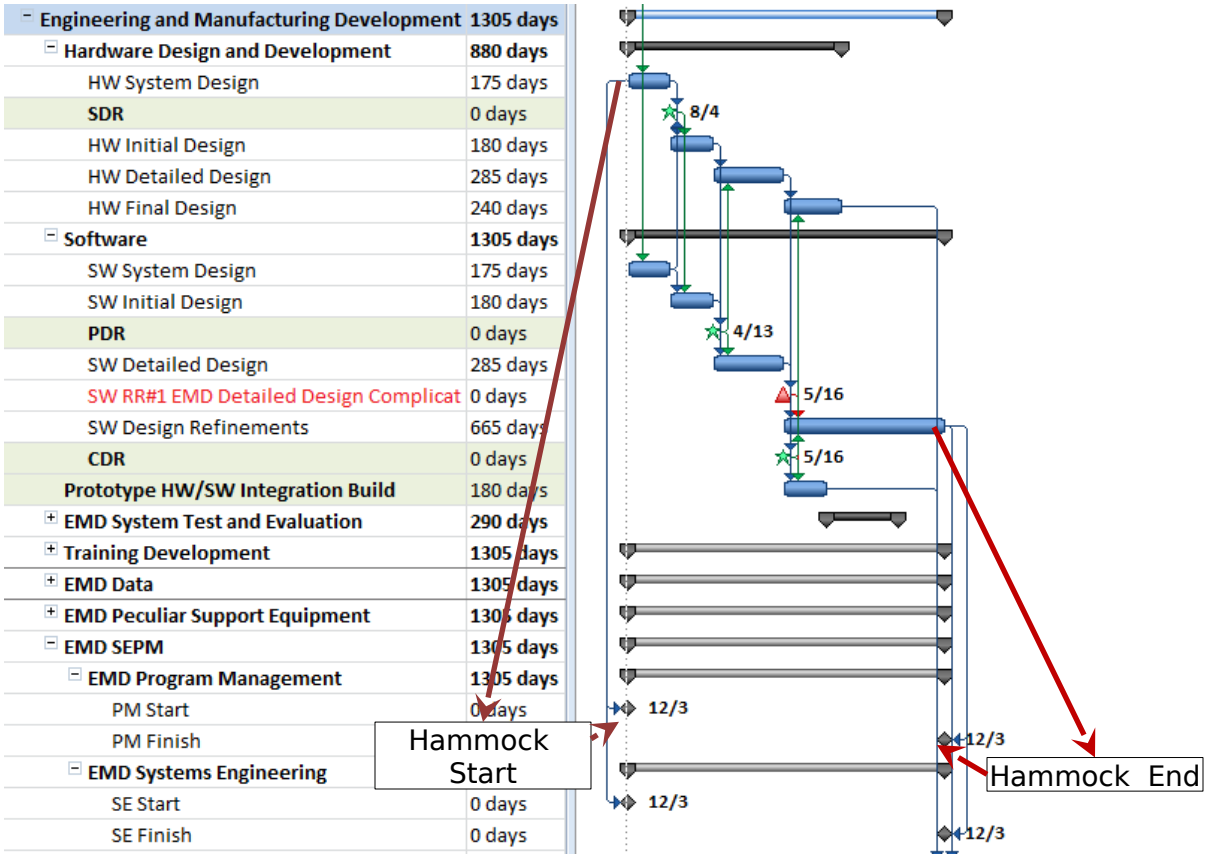

Missile System
Engineering and Manufacturing Development
Air Vehicle
Design & Development
Prototypes
Software
System Engineering
Program Management
System Test and Evaluation
Training
Data
Peculiar Support Equipment
Production & Deployment
Air Vehicle
Airframe
Propulsion
Guidance
Payload
Air Vehicle IAT&C
System Engineering
Program Management
System Test and Evaluation
Training
Data
Peculiar Support Equipment
Initial Spares and Repair Parts
Name
Duration
Missile System Project 2348 days
Contract Award Delay 45 days
Modeled Contract Award 0 days
Engineering and Manufacturing Development 1305 days
Hardware Design and Development 880 days
Software 1305 days
Prototype HW/SW Integration Build 180 days
EMD System Test and Evaluation 290 days
Training Development 1305 days
EMD Data 1305 days
EMD Peculiar Support Equipment 1305 days
EMD SEPM 1305 days
EMD Finish 0 days
Production 1043 days
First Production Lot Contract Award 0 days
Manufacturing 1043 days
Training 1043 days
Production System Test and Evaluation 843 days
Production Data 1043 days
Production Peculiar Support Equipment 215 days
Initial Spares and Repair Parts 1043 days
Production SEPM 1043 days
Final Review and Delivery (End of Project) 0 days
1st Quarter
1st Quarter
1st Quarter
1st Quarter
1st Quarter
Feb
Jan
Dec
Nov
Oct
Sep
Aug
Jul
Jun
May
Apr
Mar
12/2
12/3
12/3
12/1

Figure B-7


Engineering and Manufacturing Development 1305 days
Hardware Design and Development 880 days
HW System Design 175 days
SDR 0 days
HW Initial Design 180 days
HW Detailed Design 285 days
HW Final Design 240 days
Software 1305 days
SW System Design 175 days
SW Initial Design 180 days
PDR 0 days
SW Detailed Design 285 days
SW RR#1 EMD Detailed Design Complicat 0 days
SW Design Refinements 665 days
CDR 0 days
Prototype HW/SW Integration Build 180 days
EMD System Test and Evaluation 290 days
Training Development 1305 days
EMD Data 1305 days
EMD Peculiar Support Equipment 1305 days
EMD SEPM 1305 days
EMD Program Management 1305 days
PM Start 0 days
PM Finish
EMD Systems Engineering
SE Start 0 days
SE Finish 0 days
8/4
4/13
5/16
5/16
12/3
12/3
12/3
12/3
Hammock Start
Hammock End

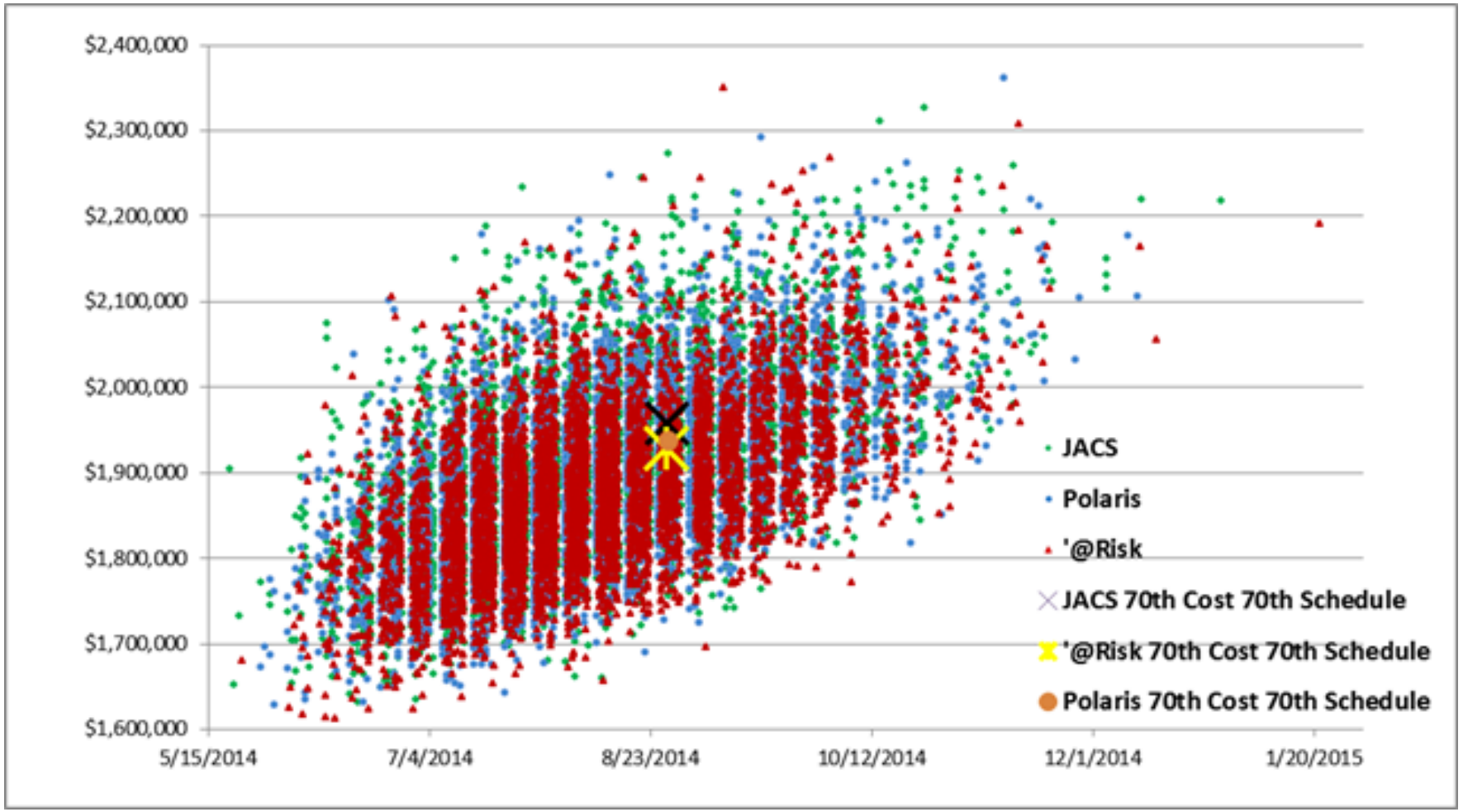
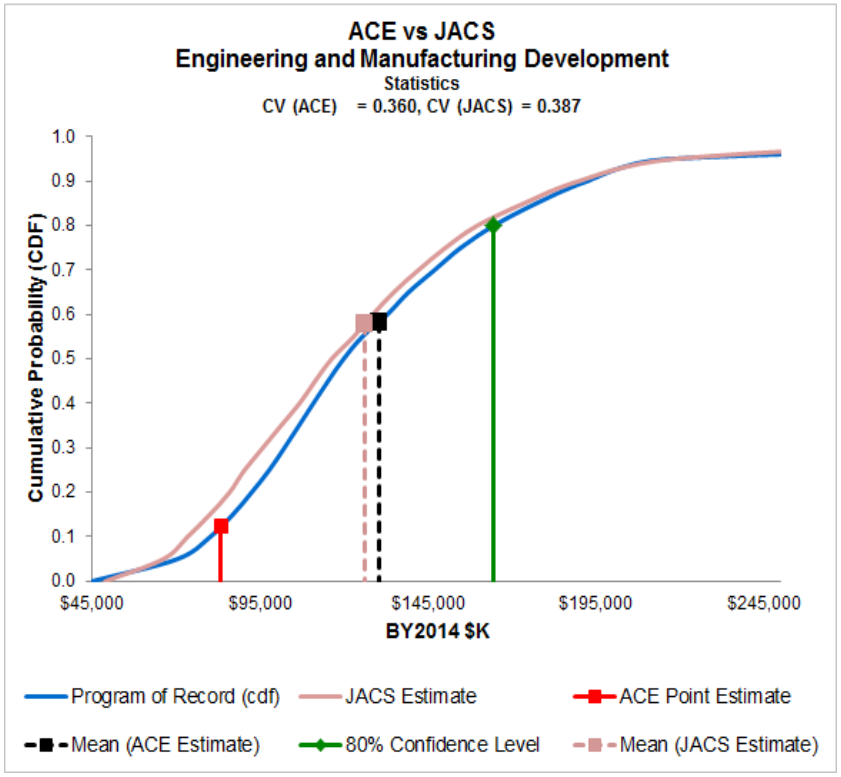

$2,400,000
$2,300,000
$2,200,000
$2,100,000
$2,000,000
$1,900,000
$1,800,000
$1,700,000
$1,600,000
5/15/2014
7/4/2014
8/23/2014
10/12/2014
12/1/2014
1/20/2015
JACS
Polaris
'@Risk
JACS 70th Cost 70th Schedule
'@Risk 70th Cost 70th Schedule
Polaris 70th Cost 70th Schedule

Figure B-10


ACE vs JACS
Engineering and Manufacturing Development
Statistics
CV (ACE) = 0.360, CV (JACS) = 0.387
Cumulative Probability (CDF)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
$45,000
$95,000
$145,000
$195,000
$245,000
BY2014 $K
Program of Record (cdf)
JACS Estimate
ACE Point Estimate
Mean (ACE Estimate)
80% Confidence Level
Mean (JACS Estimate)

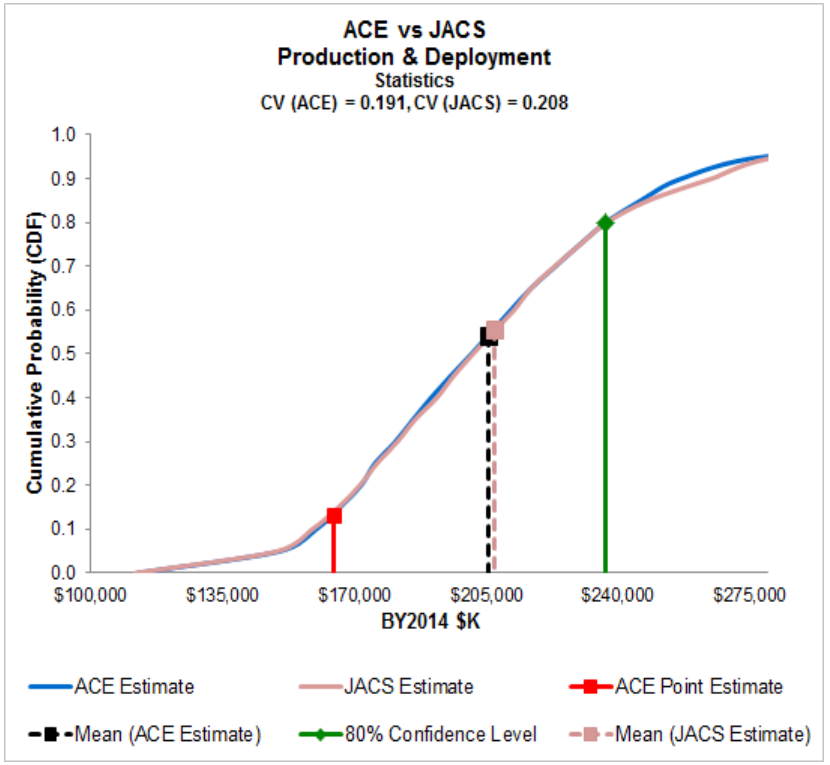
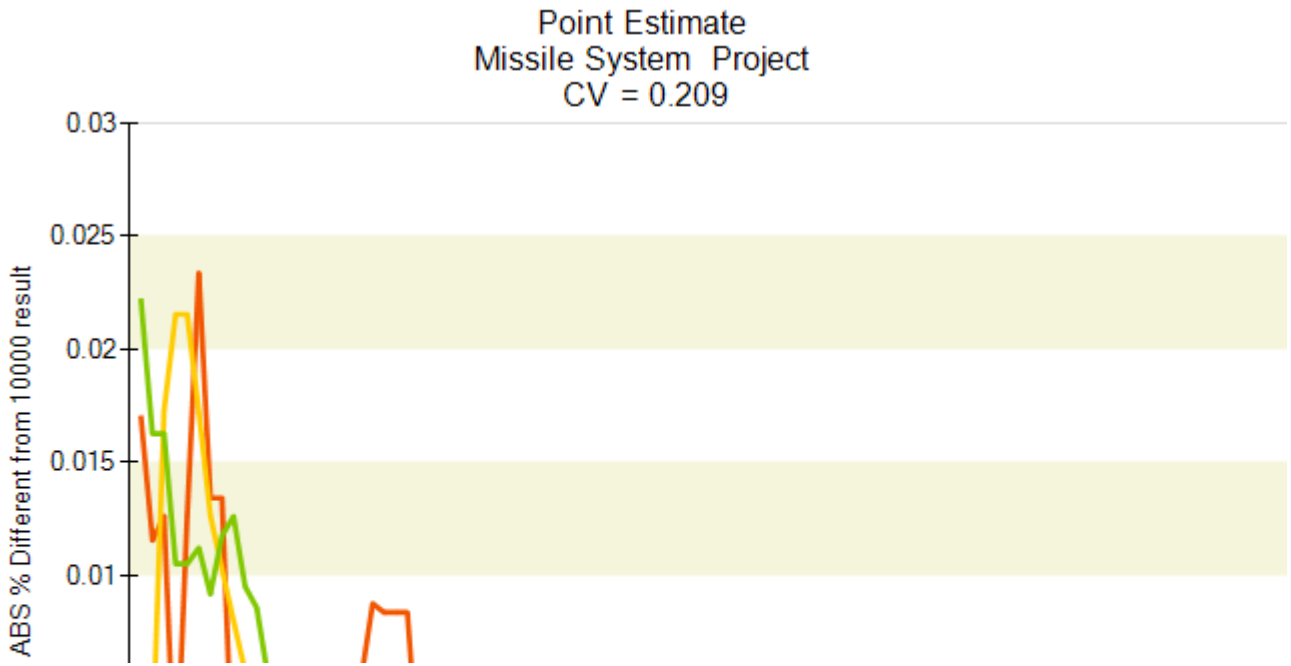
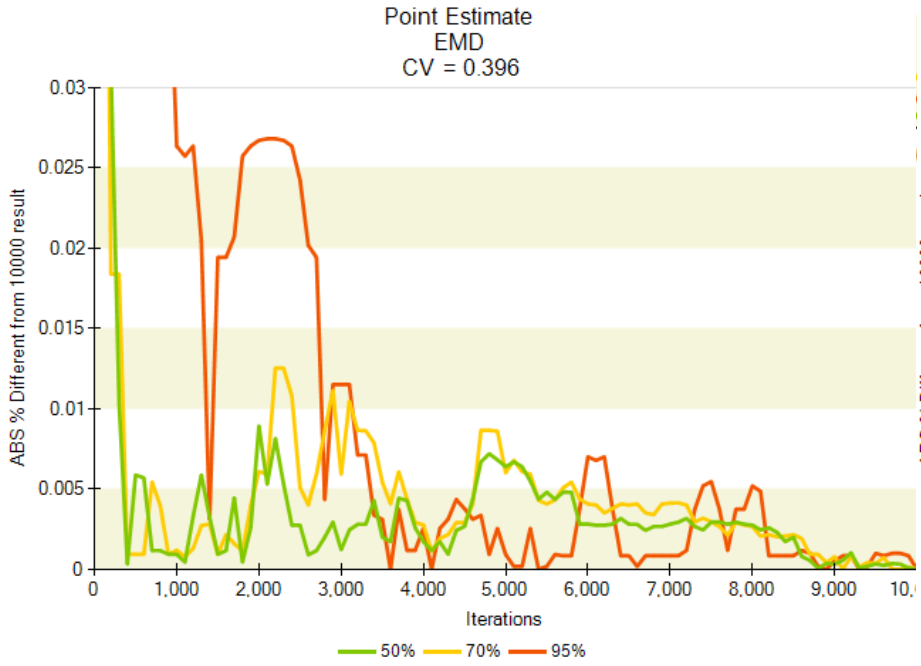

ACE vs JACS
Production & Deployment
Statistics
CV (ACE) = 0.191, CV (JACS) = 0.208
Cumulative Probability (CDF)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
$100,000
$135,000
$170,000
$205,000
$240,000
$275,000
BY2014 $K
ACE Estimate
JACS Estimate
ACE Point Estimate
Mean (ACE Estimate)
80% Confidence Level
Mean (JACS Estimate)

Figure B-16


Point Estimate
Missile System Project
CV = 0.209
ABS % Different from 10000 result
0.03
0.025
0.02
0.015
0.01


Point Estimate
EMD
CV = 0.396
ABS % Different from 10000 result
0.03
0.025
0.02
0.015
0.01
0.005
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
Iterations
50%
70%
95%

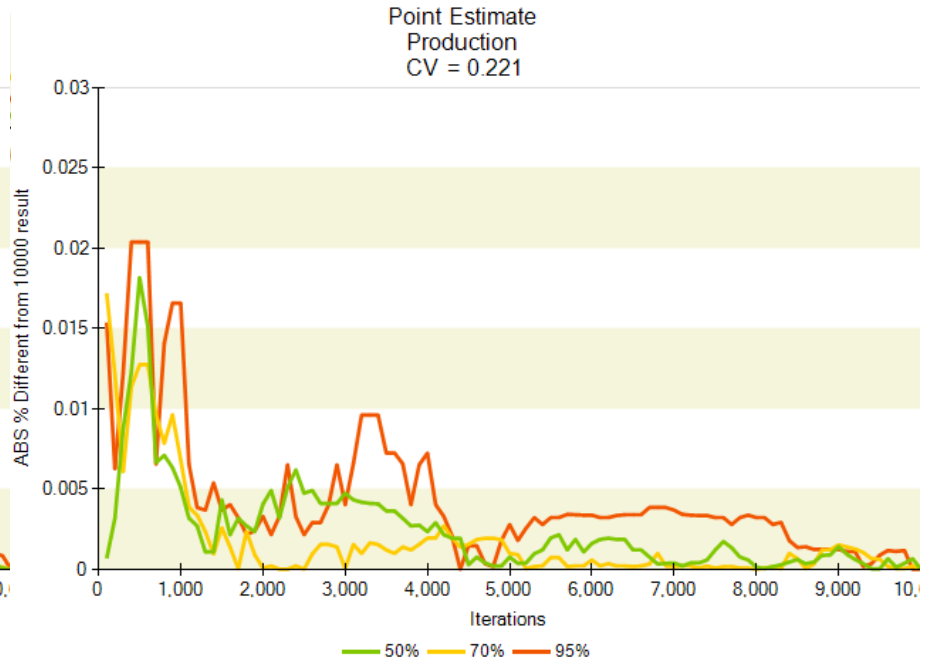

Point Estimate
Production
CV = 0.221
ABS % Different from 10000 result
0.03
0.025
0.02
0.015
0.01
0.005
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
Iterations
50%
70%
95%

Figure 8-17

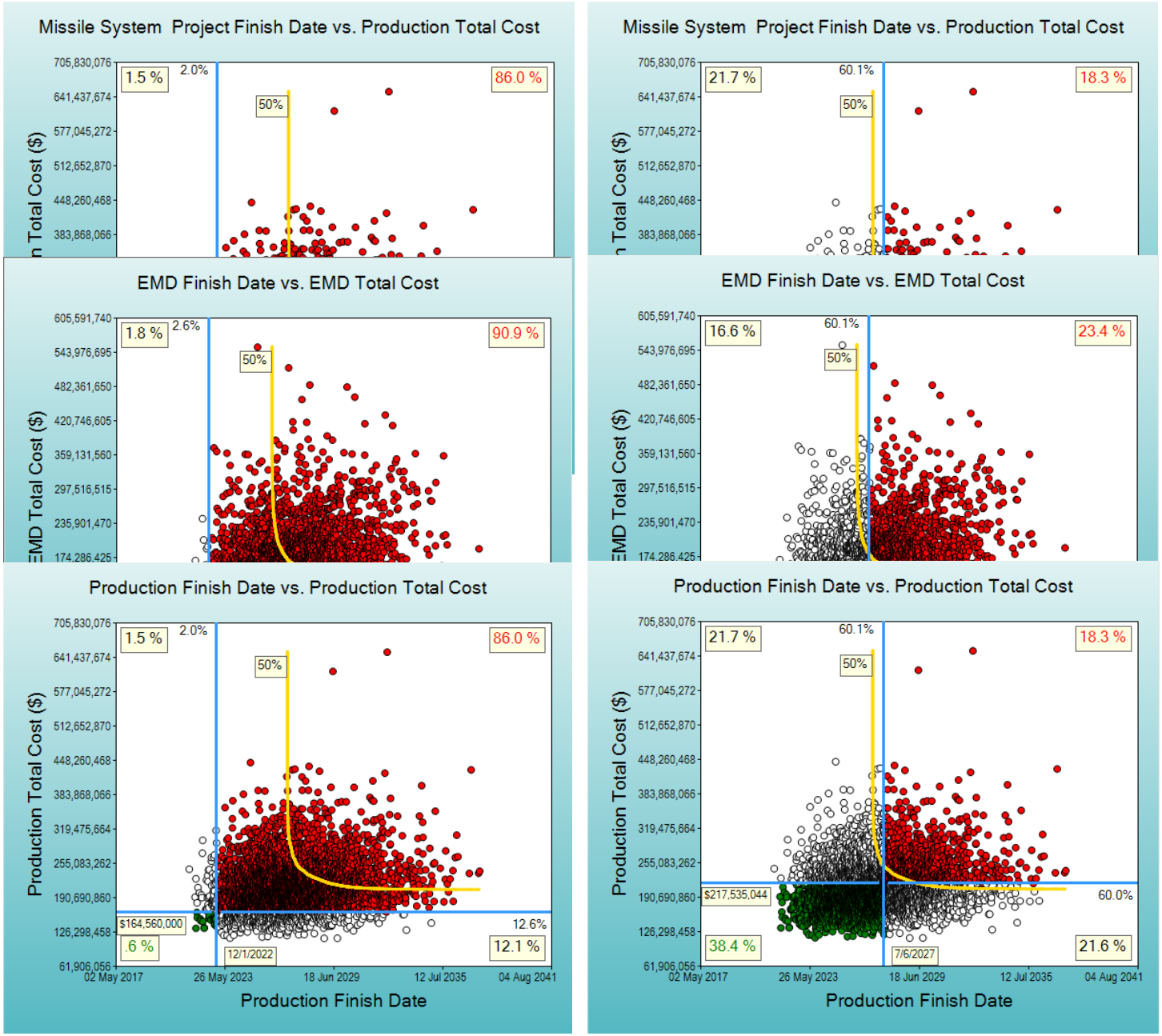
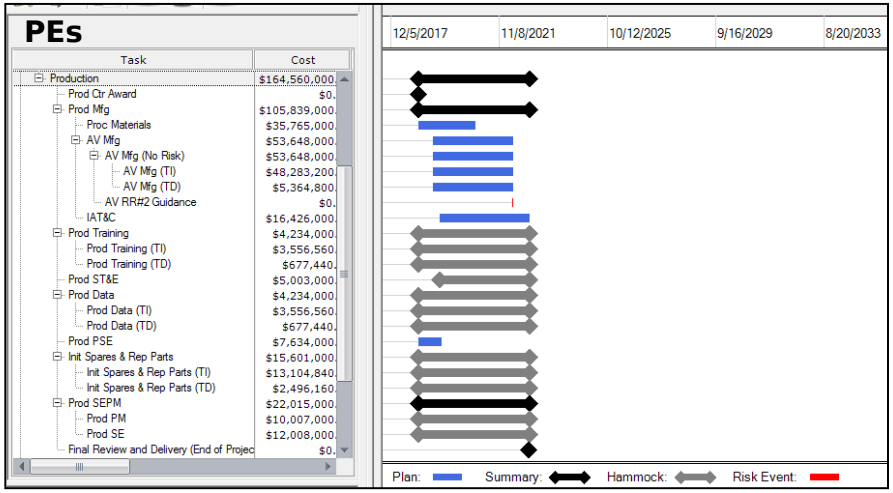
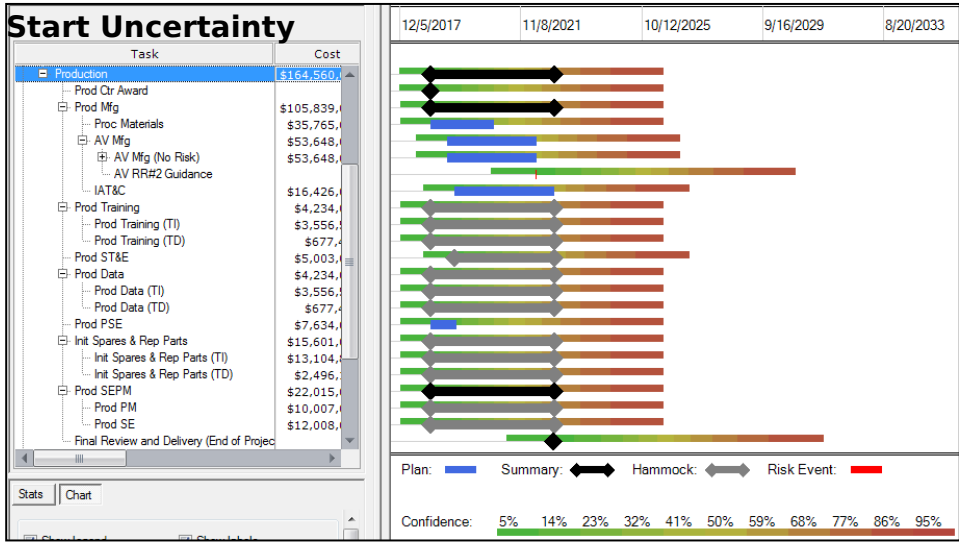
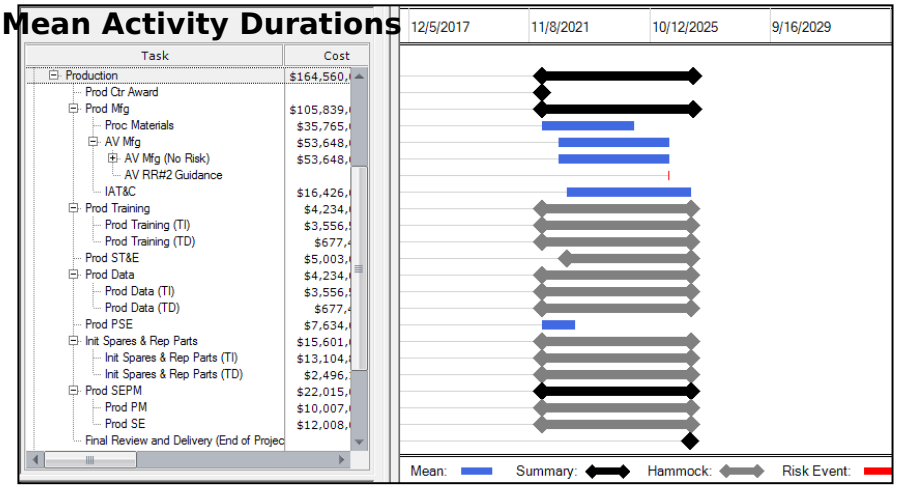

Missile System Project Finish Date vs. Production Total Cost
705,830,076
641,437,674
577,045,272
512,652,870
448,260,468
383,868,066
1.5 %
2.0%
50%
86.0 %
21.7 %
60.1%
18.3 %
EMD Finish Date vs. EMD Total Cost
EMD Total Cost ($)
605,591,740
543,976,695
482,361,650
420,746,605
359,131,560
297,516,515
235,901,470
174,286,425
1.8 %
2.6%
90.9 %
16.6 %
60.1%
23.4 %
Production Finish Date vs. Production Total Cost
Production Total Cost ($)
319,475,664
255,083,262
190,690,860
126,298,458
61,906,056
$164,560,000
.6 %
12/1/2022
12.6%
12.1 %
$217,535,044
38.4 %
7/6/2027
60.0%
21.6 %
02 May 2017
26 May 2023
18 Jun 2029
12 Jul 2035
04 Aug 2041
Production Finish Date

Figure B-19


PEs
Task
Cost
Production $164,560,000.
Prod Ctr Award $0.
Prod Mfg $105,839,000.
Proc Materials $35,765,000.
AV Mfg $53,648,000.
AV Mfg (No Risk) $53,648,000.
AV Mfg (TI) $48,283,200.
AV Mfg (TD) $5,364,800.
AV RR#2 Guidance $0.
IAT&C $16,426,000.
Prod Training $4,234,000.
Prod Training (TI) $3,556,560.
Prod Training (TD) $677,440.
Prod ST&E $5,003,000.
Prod Data $4,234,000.
Prod Data (TI) $3,556,560.
Prod Data (TD) $677,440.
Prod PSE $7,634,000.
Init Spares & Rep Parts $15,601,000.
Init Spares & Rep Parts (TI) $13,104,840.
Init Spares & Rep Parts (TD) $2,496,160.
Prod SEPM $22,015,000.
Prod PM $10,007,000.
Prod SE $12,008,000.
Final Review and Delivery (End of Projec $0.
12/5/2017
11/8/2021
10/12/2025
9/16/2029
8/20/2033
Plan:
Summary:
Hammock:
Risk Event:


Start Uncertainty
Task
Cost
Production $164,560,
Prod Ctr Award
Prod Mfg $105,839,
Proc Materials $35,765,
AV Mfg $53,648,
AV Mfg (No Risk) $53,648,
AV RR#2 Guidance
IAT&C $16,426,
Prod Training $4,234,
Prod Training (TI) $3,556,
Prod Training (TD) $677,
Prod ST&E $5,003,
Prod Data $4,234,
Prod Data (TI) $3,556,
Prod Data (TD) $677,
Prod PSE $7,634,
Init Spares & Rep Parts $15,601,
Init Spares & Rep Parts (TI) $13,104,
Init Spares & Rep Parts (TD) $2,496,
Prod SEPM $22,015,
Prod PM $10,007,
Prod SE $12,008,
Final Review and Delivery (End of Projec
Stats
Chart
12/5/2017
11/8/2021
10/12/2025
9/16/2029
8/20/2033
Plan:
Summary:
Hammock:
Risk Event:
Confidence:
5%
14%
23%
32%
41%
50%
59%
68%
77%
86%
95%


Mean Activity Durations
Task
Cost
Production $164,560,
Prod Ctr Award
Prod Mfg $105,839,
Proc Materials $35,765,
AV Mfg $53,648,
AV Mfg (No Risk) $53,648,
AV RR#2 Guidance
IAT&C $16,426,
Prod Training $4,234,
Prod Training (TI) $3,556,
Prod Training (TD) $677,
Prod ST&E $5,003,
Prod Data $4,234,
Prod Data (TI) $3,556,
Prod Data (TD) $677,
Prod PSE $7,634,
Init Spares & Rep Parts $15,601,
Init Spares & Rep Parts (TI) $13,104,
Init Spares & Rep Parts (TD) $2,496,
Prod SEPM $22,015,
Prod PM $10,007,
Prod SE $12,008,
Final Review and Delivery (End of Projec
12/5/2017
11/8/2021
10/12/2025
9/16/2029
Mean:
Summary:
Hammock:
Risk Event:

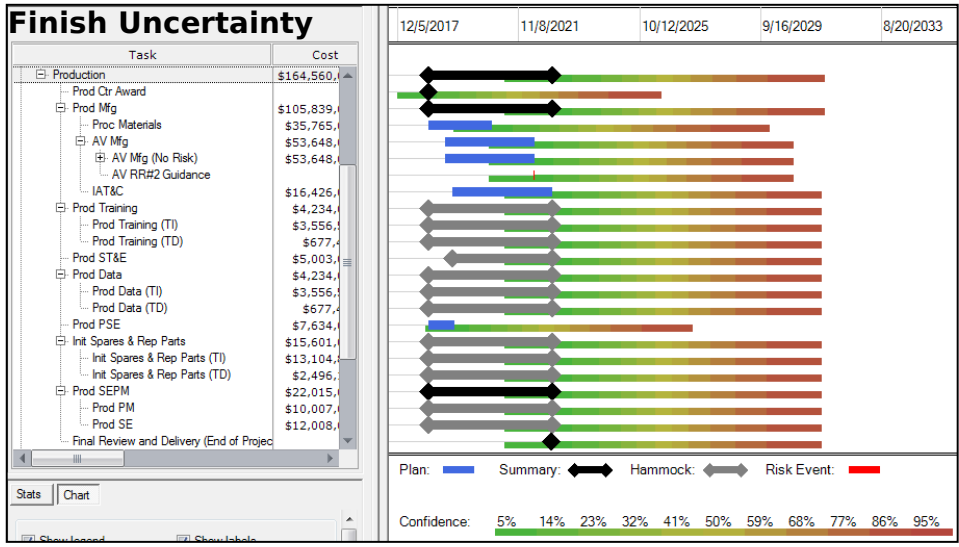
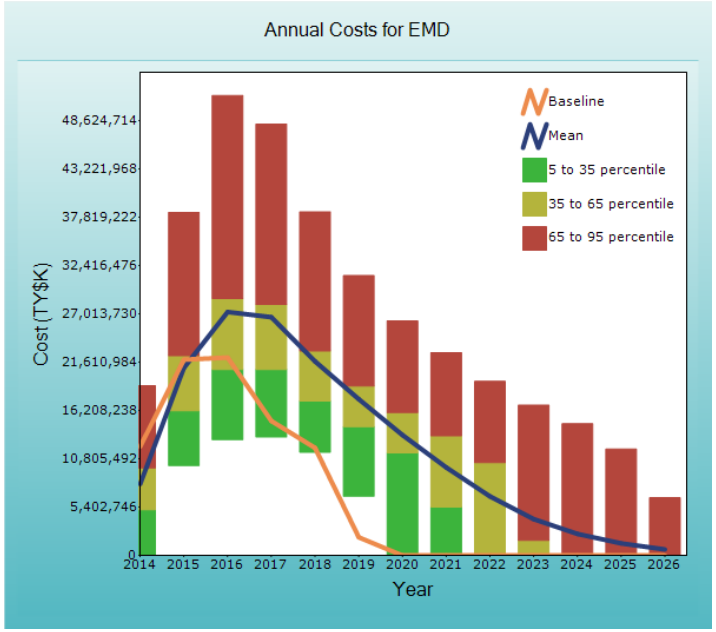
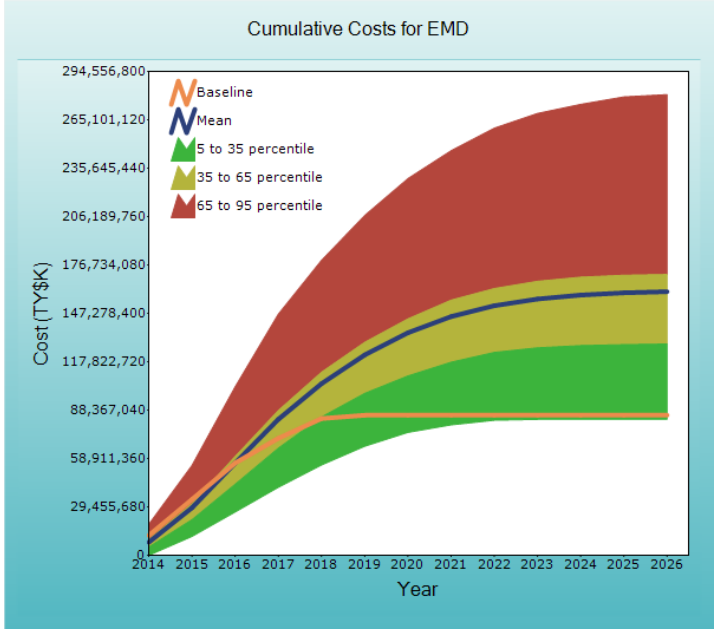

Finish Uncertainty
Task
Cost
Production $164,560,
Prod Ctr Award
Prod Mfg $105,839,
Proc Materials $35,765,
AV Mfg $53,648,
AV Mfg (No Risk) $53,648,
AV RR#2 Guidance
IAT&C $16,426,
Prod Training $4,234,
Prod Training (TI) $3,556,
Prod Training (TD) $677,
Prod ST&E $5,003,
Prod Data $4,234,
Prod Data (TI) $3,556,
Prod Data (TD) $677,
Prod PSE $7,634,
Init Spares & Rep Parts $15,601,
Init Spares & Rep Parts (TI) $13,104,
Init Spares & Rep Parts (TD) $2,496,
Prod SEPM $22,015,
Prod PM $10,007,
Prod SE $12,008,
Final Review and Delivery (End of Projec
Stats
Chart
12/5/2017
11/8/2021
10/12/2025
9/16/2029
8/20/2033
Plan:
Summary:
Hammock:
Risk Event:
Confidence:
5%
14%
23%
32%
41%
50%
59%
68%
77%
86%
95%

Figure B-20


Annual Costs for EMD
Cost (TY$K)
48,624,714
43,221,968
37,819,222
32,416,476
27,013,730
21,610,984
16,208,238
10,805,492
5,402,746
0
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
Year
Baseline
Mean
5 to 35 percentile
35 to 65 percentile
65 to 95 percentile


Cumulative Costs for EMD
Cost (TY$K)
294,556,800
265,101,120
235,645,440
206,189,760
176,734,080
147,278,400
117,822,720
88,367,040
58,911,360
29,455,680
0
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026
Year
Baseline
Mean
5 to 35 percentile
35 to 65 percentile
65 to 95 percentile

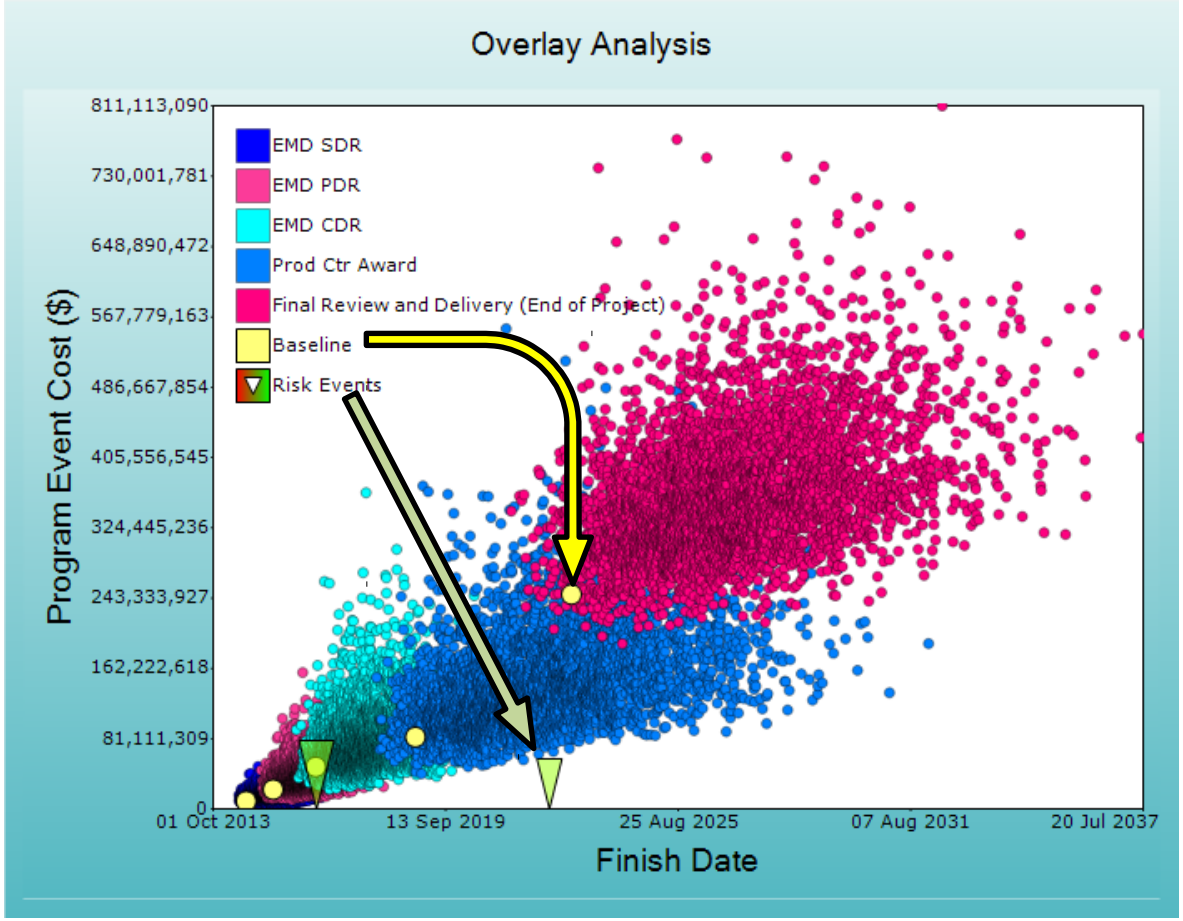
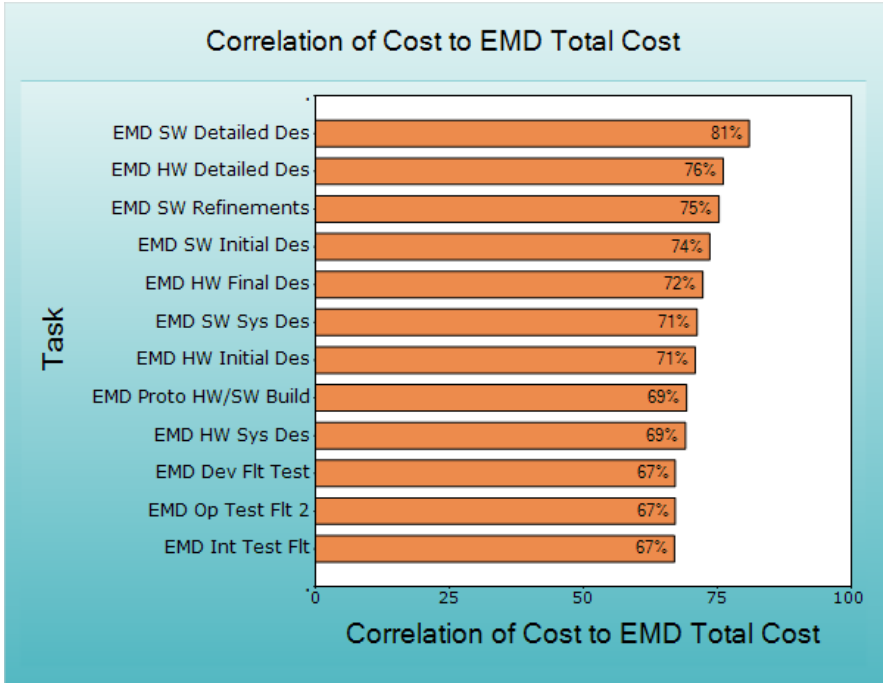

Overlay Analysis
811,113,090
730,001,781
648,890,472
567,779,163
486,667,854
405,556,545
324,445,236
243,333,927
162,222,618
81,111,309
0
Program Event Cost ($)
EMD SDR
EMD PDR
EMD CDR
Prod Ctr Award
Final Review and Delivery (End of Project)
Baseline
Risk Events
01 Oct 2013
13 Sep 2019
25 Aug 2025
07 Aug 2031
20 Jul 2037
Finish Date

Figure B-22


Correlation of Cost to EMD Total Cost
Task
EMD SW Detailed Des
EMD HW Detailed Des
EMD SW Refinements
EMD SW Initial Des
EMD HW Final Des
EMD SW Sys Des
EMD HW Initial Des
EMD Proto HW/SW Build
EMD HW Sys Des
EMD Dev Flt Test
EMD Op Test Flt 2
EMD Int Test Flt
81%
76%
75%
74%
72%
71%
71%
69%
69%
67%
67%
67%
0
25
50
75
100
Correlation of Cost to EMD Total Cost

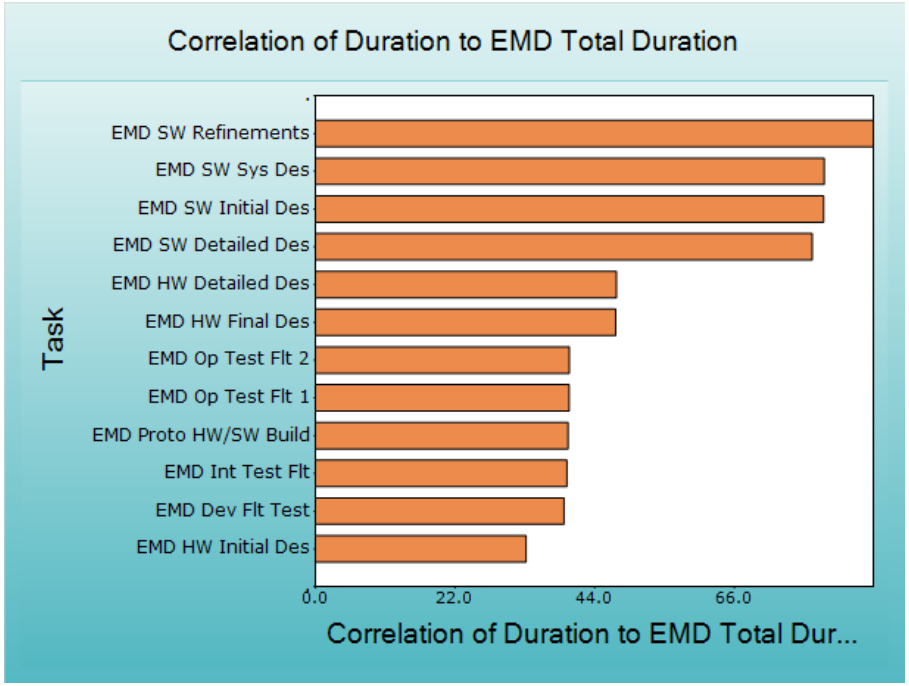
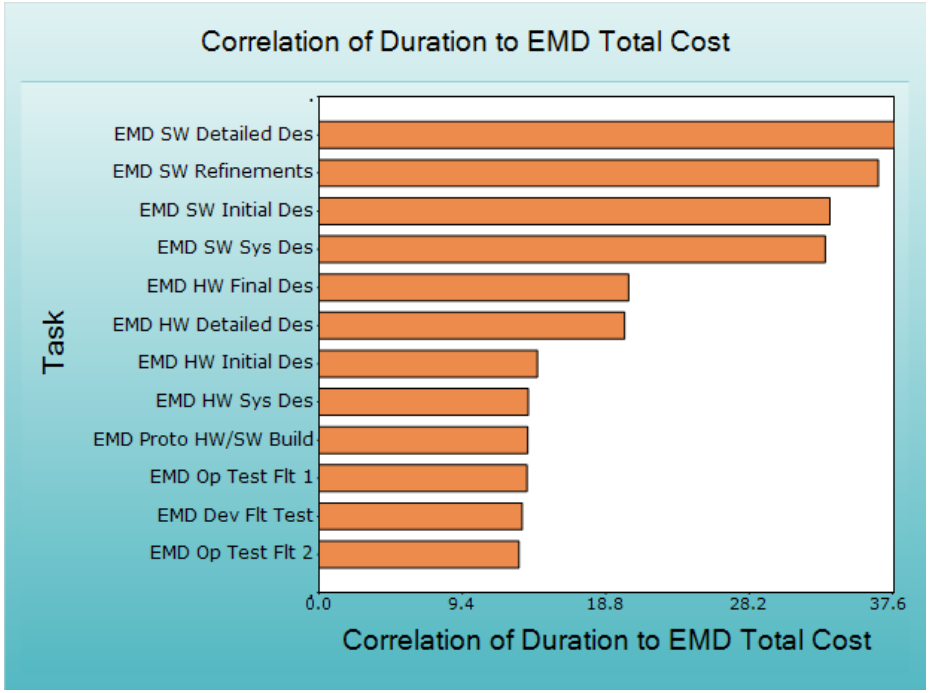

Correlation of Duration to EMD Total Duration
Task
EMD SW Refinements
EMD SW Sys Des
EMD SW Initial Des
EMD SW Detailed Des
EMD HW Detailed Des
EMD HW Final Des
EMD Op Test Flt 2
EMD Op Test Flt 1
EMD Proto HW/SW Build
EMD Int Test Flt
EMD Dev Flt Test
EMD HW Initial Des
0.0
22.0
44.0
66.0
Correlation of Duration to EMD Total Dur...

Figure B-23


Correlation of Duration to EMD Total Cost
Task
EMD SW Detailed Des
EMD SW Refinements
EMD SW Initial Des
EMD SW Sys Des
EMD HW Final Des
EMD HW Detailed Des
EMD HW Initial Des
EMD HW Sys Des
EMD Proto HW/SW Build
EMD Op Test Flt 1
EMD Dev Flt Test
EMD Op Test Flt 2
0.0
9.4
18.8
28.2
37.6
Correlation of Duration to EMD Total Cost

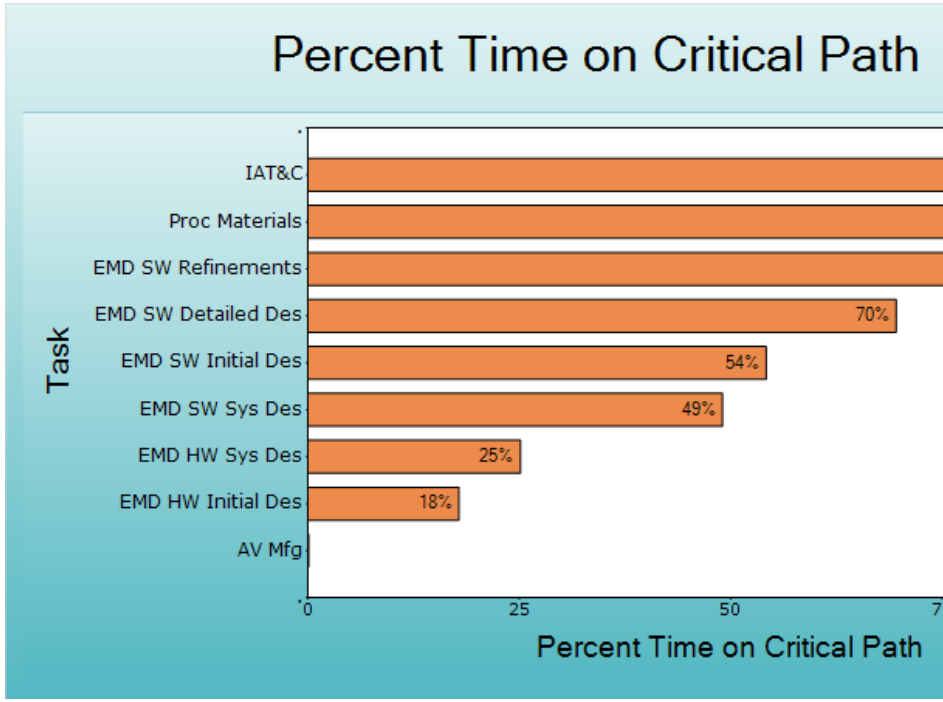

Percent Time on Critical Path
Task
IAT&C
Proc Materials
EMD SW Refinements
EMD SW Detailed Des
EMD SW Initial Des
EMD SW Sys Des
EMD HW Sys Des
EMD HW Initial Des
AV Mfg
70%
54%
49%
25%
18%
0
25
50
Percent Time on Critical Path

Figure B-24

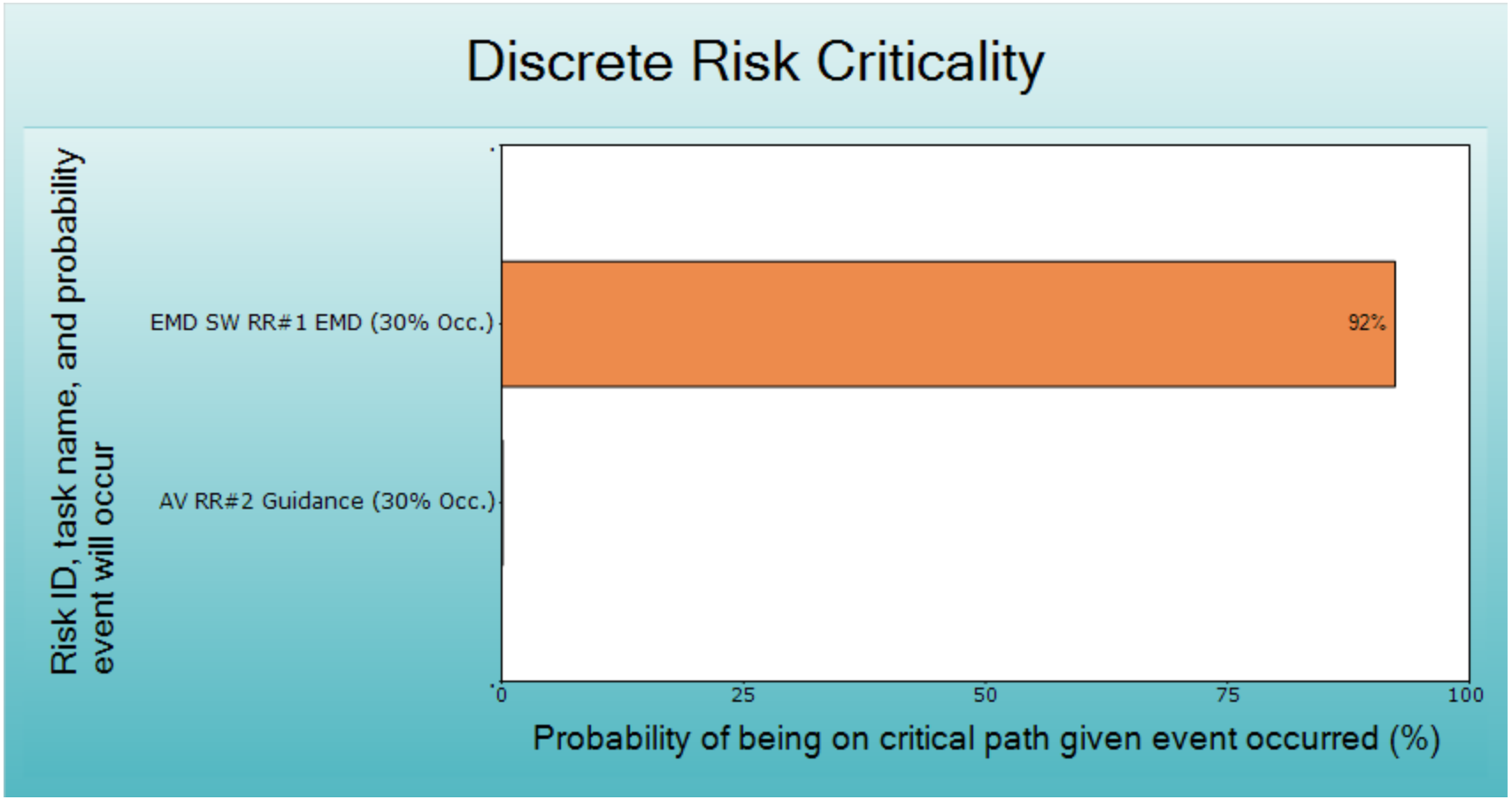
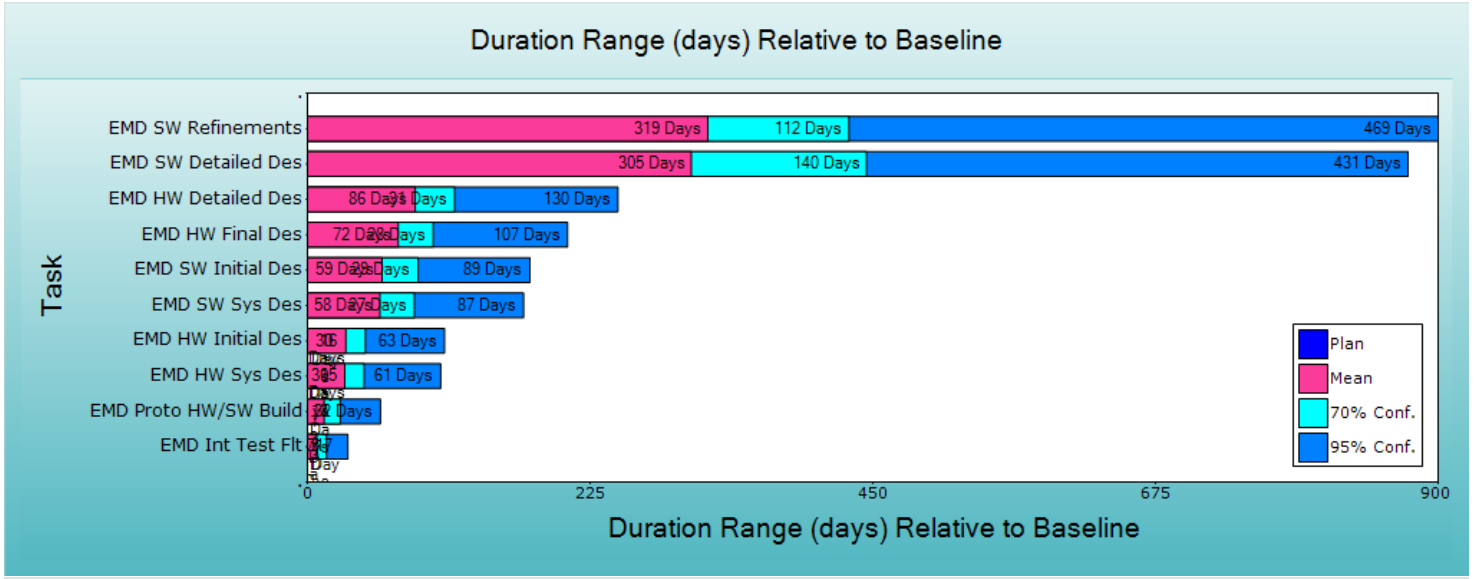
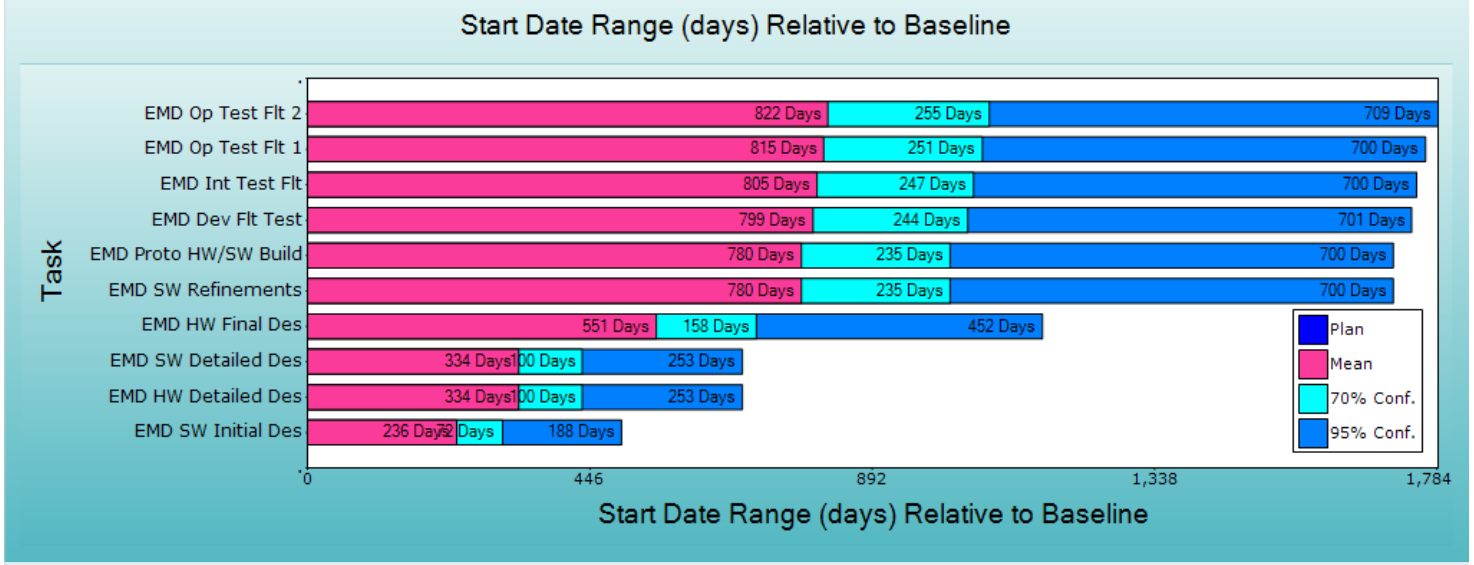
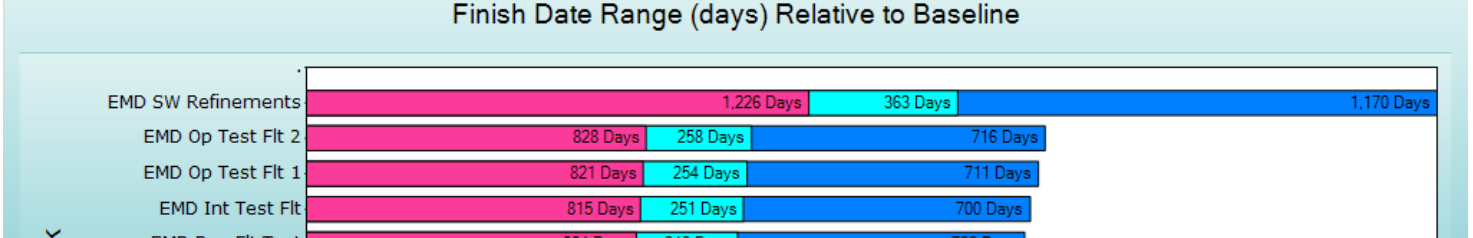

Discrete Risk Criticality
Risk ID, task name, and probability event will occur
EMD SW RR#1 EMD (30% Occ.)
AV RR#2 Guidance (30% Occ.)
92%
0
25
50
75
100
Probability of being on critical path given event occurred (%)

Figure B-24

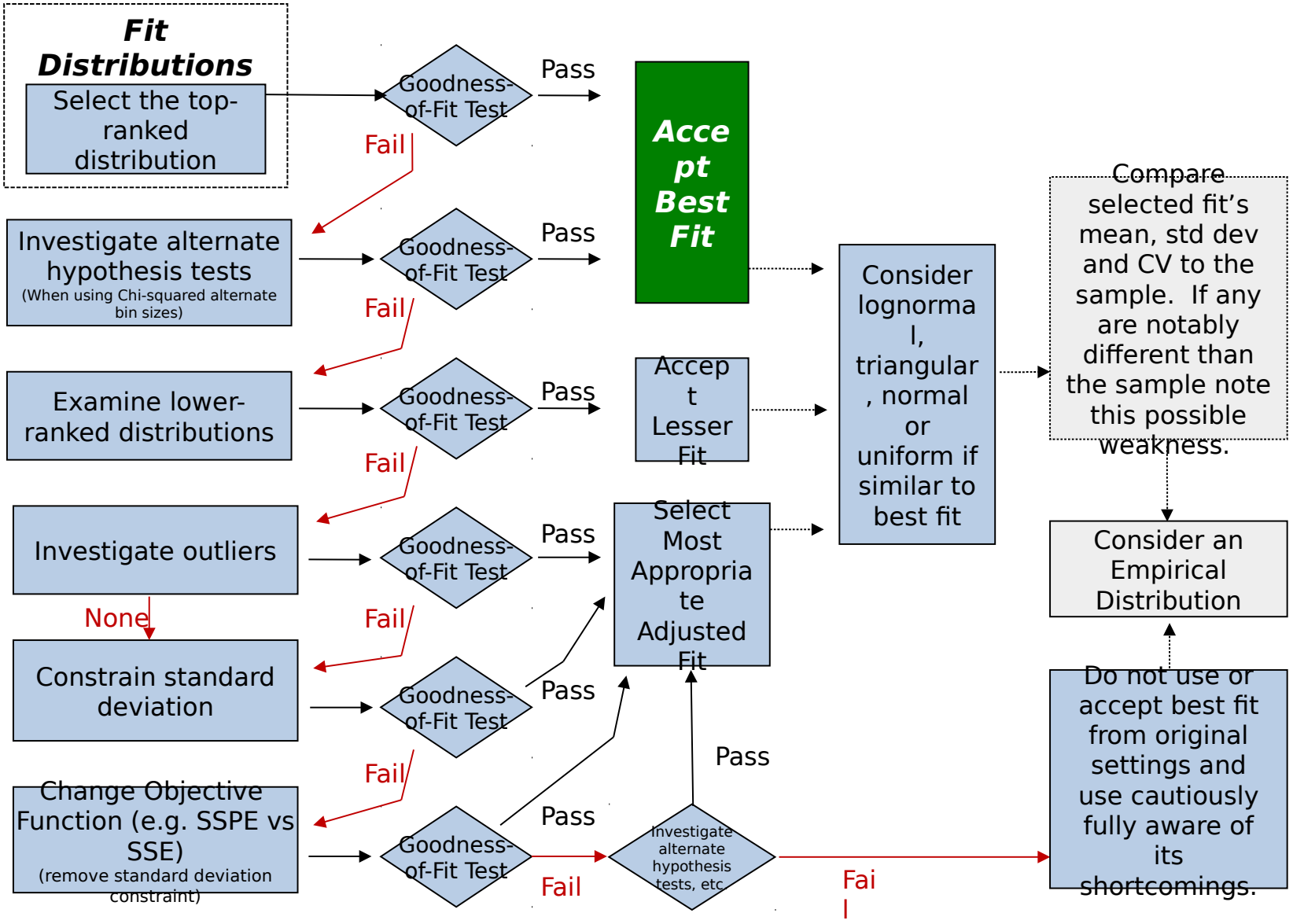

Duration Range (days) Relative to Baseline
Task
EMD SW Refinements
EMD SW Detailed Des
EMD HW Detailed Des
EMD HW Final Des
EMD SW Initial Des
EMD SW Sys Des
EMD HW Initial Des
EMD HW Sys Des
EMD Proto HW/SW Build
EMD Int Test Flt
319 Days
112 Days
469 Days
305 Days
140 Days
431 Days
130 Days
107 Days
89 Days
87 Days
63 Days
61 Days
Plan
Mean
70% Conf.
95% Conf.
0
225
450
675
900
Duration Range (days) Relative to Baseline


Start Date Range (days) Relative to Baseline
Task
EMD Op Test Flt 2
EMD Op Test Flt 1
EMD Int Test Flt
EMD Dev Flt Test
EMD Proto HW/SW Build
EMD SW Refinements
EMD HW Final Des
EMD SW Detailed Des
EMD HW Detailed Des
EMD SW Initial Des
822 Days
255 Days
709 Days
815 Days
251 Days
700 Days
805 Days
247 Days
700 Days
799 Days
244 Days
701 Days
780 Days
235 Days
700 Days
780 Days
235 Days
700 Days
551 Days
158 Days
452 Days
334 Days
253 Days
334 Days
253 Days
236 Days
188 Days
Plan
Mean
70% Conf.
95% Conf.
0
446
892
1,338
1,784
Start Date Range (days) Relative to Baseline

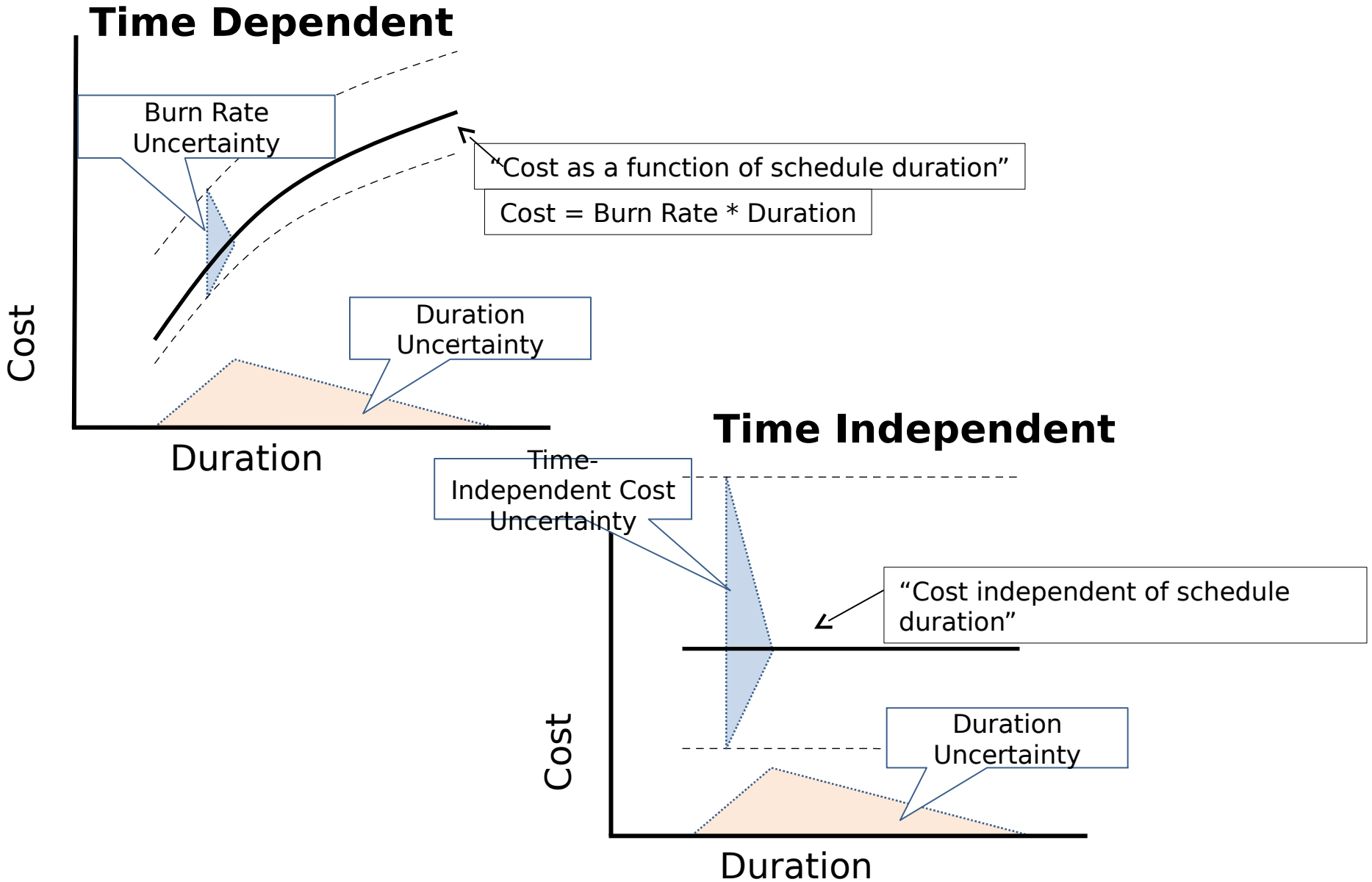

Finish Date Range (days) Relative to Baseline
EMD SW Refinements
EMD Op Test Flt 2
EMD Op Test Flt 1
EMD Int Test Flt
1,226 Days
363 Days
1,170 Days
828 Days
258 Days
716 Days
821 Days
254 Days
711 Days
815 Days
251 Days
700 Days

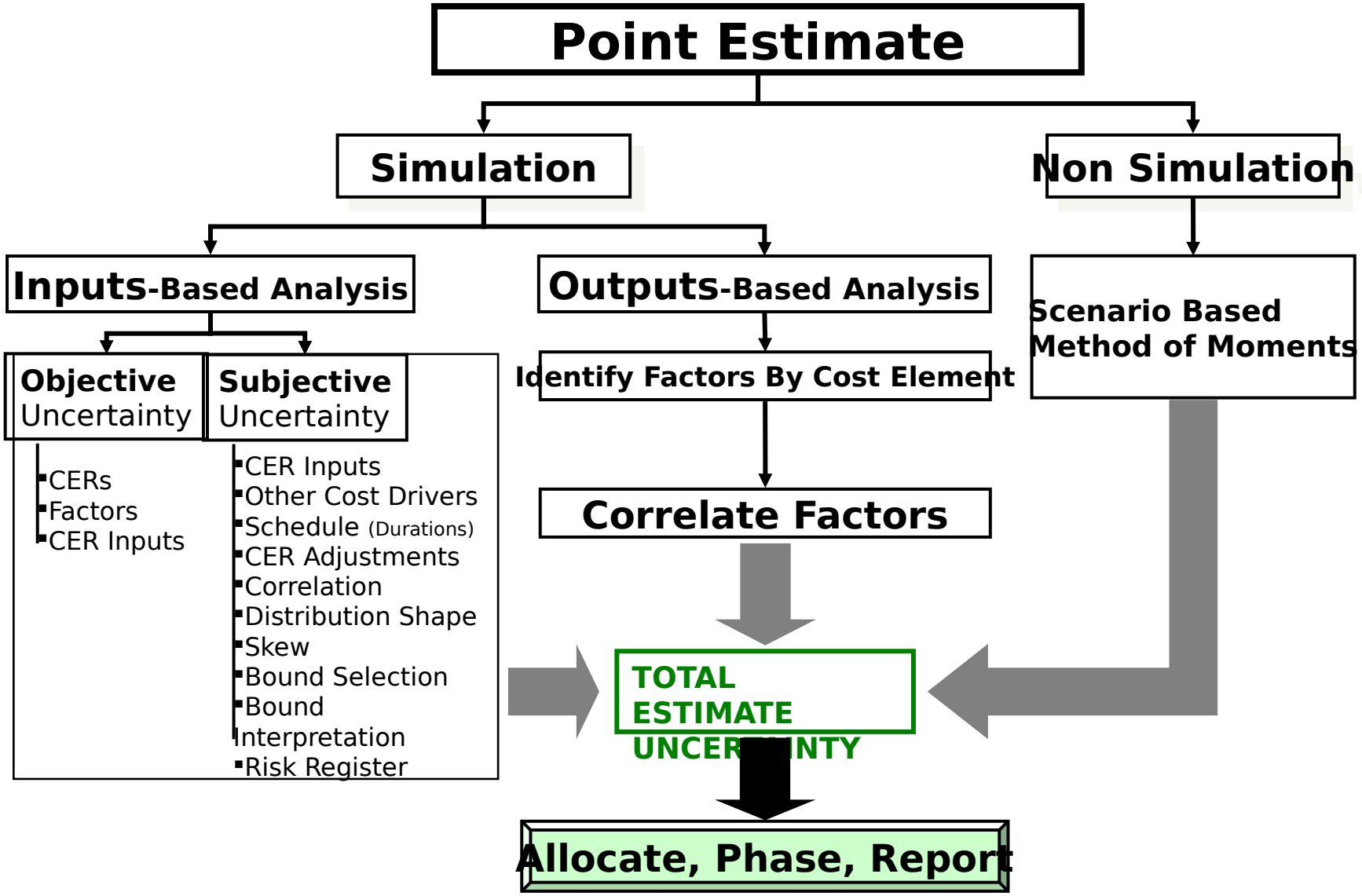
BACKUP

Figure 2-11

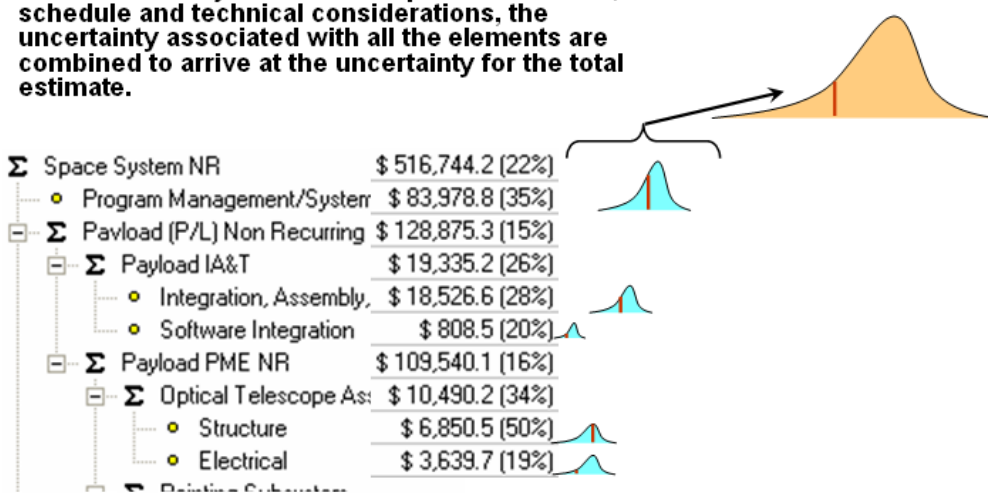

Fit Distributions
Select the top-ranked distribution
Goodness-of-Fit Test
Pass
Fail
Accept Best Fit
Investigate alternate hypothesis tests
(When using Chi-squared alternate bin sizes)
Goodness-of-Fit Test
Pass
Fail
Examine lower-ranked distributions
Goodness-of-Fit Test
Pass
Accept Lesser Fit
Fail
Investigate outliers
Goodness-of-Fit Test
Pass
Select Most Appropriate Adjusted Fit
None
Fail
Constrain standard deviation
Goodness-of-Fit Test
Pass
Fail
Change Objective Function (e.g. SSPE vs SSE)
(remove standard deviation constraint)
Goodness-of-Fit Test
Pass
Pass
Investigate alternate hypothesis tests, etc
Fail
Fail
Consider lognormal, triangular, normal or uniform if similar to best fit
Compare selected fit's mean, std dev and CV to the sample. If any are notably different than the sample note this possible weakness.
Consider an Empirical Distribution
Do not use or accept best fit from original settings and use cautiously fully aware of its shortcomings.

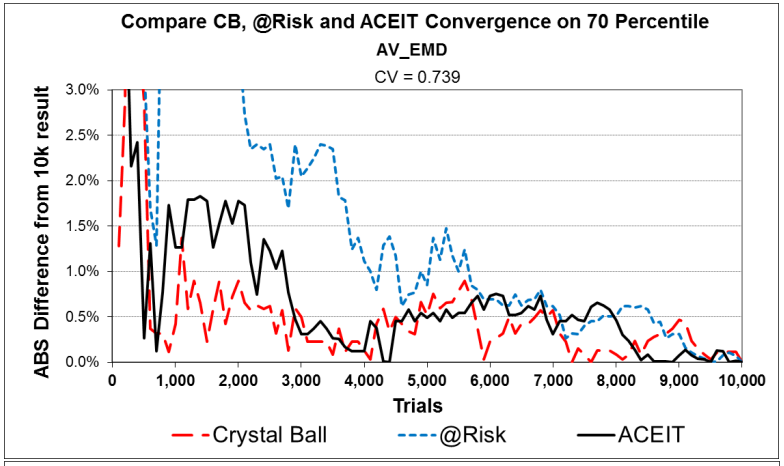
TI vs TD

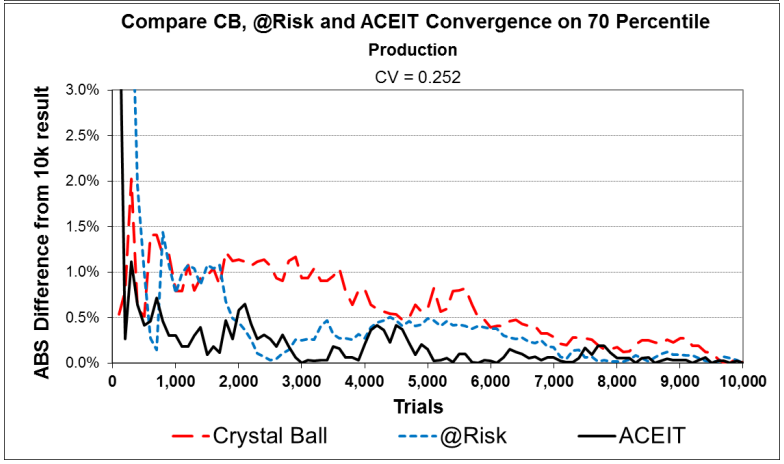

Time Dependent
Burn Rate Uncertainty
"Cost as a function of schedule duration"
Cost = Burn Rate * Duration
Duration Uncertainty
Cost
Duration
Time Independent
Time-Independent Cost Uncertainty
"Cost independent of schedule duration"
Duration Uncertainty
Cost
Duration


Point Estimate
Simulation
Non Simulation
Inputs-Based Analysis
Outputs-Based Analysis
Scenario Based
Method of Moments
Objective
Uncertainty
Subjective
Uncertainty
CERs
Factors
CER Inputs
CER Inputs
Other Cost Drivers
Schedule (Durations)
CER Adjustments
Correlation
Distribution Shape
Skew
Bound Selection
Bound
Interpretation
Risk Register
Identify Factors By Cost Element
Correlate Factors
TOTAL
ESTIMATE
UNCERTAINTY
Allocate, Phase, Report

With suitable adjustments to capture correlation, schedule and technical considerations, the uncertainty associated with all the elements are combined to arrive at the uncertainty for the total estimate.




Compare CB, @Risk and ACEIT Convergence on 70 Percentile
AV_EMD
CV = 0.739
ABS Difference from 10k result
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Trials
Crystal Ball
@Risk
ACEIT


Compare CB, @Risk and ACEIT Convergence on 70 Percentile
Production
CV = 0.252
ABS Difference from 10k result
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Trials
Crystal Ball
@Risk
ACEIT